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TR-8317-1

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DEMONSTRATION OF THE EARLY-ON MANPOWER REQUIREMENTS ESTIMATION METHODOLOGY: AH-64 (APACHE) AND UH-60A (BLACK HAWK) HELICOPTERS

By:

William P. Hutzler
Patricia A. Insley
Betty Lou Bantor

31 December 1983

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Management Consulting & Research, Inc. (MCR) developed a methodology for the Early-on Manpower Requirements Estimation Methodology (EMREM). The methodology is demonstrated using two systems: the AH-64 (APACHE) helicopter and the UH-60A (BLACK HAWK) helicopter. Included are hardware characteristics, possible baseline systems, and a description of the new system in terms of appropriate baseline systems/subsystem characteristics. Manpower requirements are estimated and translated into aptitude clusters.

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PREFACE

Management Consulting & Research, Inc. (MCR) was tasked by the Office of the Assistant Secretary of Defense for Manpower, Installations and Logistics, OASD(MI&L), under Phase I of contract MDA903-82-C-0400, to:

- develop and implement a methodology for projecting the long-term supply of manpower, by categories of aptitude, in the non-prior service youth population;
- design a procedure for determining, very early in the acquisition process, manpower demand over the life cycle of an individual weapon system;
- implement and validate the demand projection methodology by estimating manpower requirements for the Army's M1 Main Battle Tank; and
- recommend ways in which to generalize the manpower demand methodology to weapon systems in all four Services.

These four tasks have been completed and documented.[1/]

In the second phase of its work, MCR has been tasked by OASD(MRA&L) to:

- further demonstrate the applicability of the Early-On Manpower Requirements Estimation Methodology (EMREM) and test the accuracy of its estimates for both high and low technology systems; and
- extend EMREM to tri-Service application.

1/ TR-8217-1, Estimation of Manpower Requirements for Weapon Systems in the Concept Exploration Phase, Management Consulting & Research, Inc., Falls Church, Virginia, 15 April 1983.
TR-8217-2, Aptitude Content of the Non-Prior Service Youth and Enlisted Apprentice Populations: 1982-2010, Management Consulting & Research, Inc., Falls Church, Virginia, 1 December 1983.
TR-8217-3, Demonstration of the Early-On Manpower Requirements Estimation Methodology: M1 Abrams Main Battle Tank, Management Consulting & Research, Inc., Falls Church, Virginia, 30 September 1983.

This report addresses the first of the Phase II tasks listed above. It also reviews MCR's methodology for determining weapon system-specific enlisted manpower requirements during the Concept Exploration Phase of the acquisition process. Analysis performed on the second Phase II topic is separately documented.[2/]

Implementation of these manpower supply and demand methodologies is intended to provide the Department of Defense with a means to identify probable weapon system manning constraints while systems are still in the earliest stages of their acquisition planning.

2/ TR-8317-2, Tri-Service Applicability of the Early-On Manpower Requirements Estimation Methodology, Management Consulting & Research, Inc., Falls Church, Virginia, 31 December 1983.

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I. INTRODUCTION

Estimation of the manpower requirements for weapon systems that are in the early stages of their acquisition process is very important to defense planners. There are several reasons for this. First, weapon systems are becoming increasingly complex technologically. Since it takes a number of years to train individuals to operate and maintain complex systems, planning lead-time is needed to fully staff the operator and support pipelines. Second, the supply of young men and women eligible to enter military service is declining and will continue to do so until the mid-1990s. Acquisition managers and weapon system designers must be sensitive to that fact and the increasing competition for a scarce resource that will ensue. Finally, personnel costs have been and will continue to be the single largest portion of the Department of Defense budget. We should expect those costs to increase, especially in light of the declining supply of non-prior Service youth. Early estimation of manpower requirements for a weapon system may ultimately lead to better (i.e., more maintainable) designs and ensure the availability of appropriate numbers of skilled operator and support personnel.

A. BACKGROUND

Management Consulting & Research, Inc. (MCR) has been tasked by the Office of the Assistant Secretary of Defense for Manpower, Installations and Logistics, OASD(MI&L), to develop and demonstrate a methodology for projecting weapon system-specific enlisted

manpower requirements in the Concept Exploration Phase of a weapon system acquisition.[3/] The Early-On Manpower Requirements Estimation Methodology (EMREM), developed and initially demonstrated on the M1 Abrams Main Battle Tank in Phase I of this study, was developed in response to that requirement. EMREM is designed to:

- focus on enlisted military personnel involved in the operation and support of a weapon system,
- consider changes in manpower requirements that can occur during the operational life of a weapon system, and
- use readily available data.

This manpower requirements estimation methodology is designed to be compatible with MCR's proposed manpower supply projection methodology.[4/] For this reason, manpower requirements described in this report are translated into requirements for manpower in particular Aptitude Clusters.[5/] Aptitude Clusters are general groupings of similar skills and capabilities needed to qualify for jobs in the military.

MCR has been tasked in Phase II to further demonstrate EMREM on two additional weapon systems, the AH-64 Apache and the UH-60A

3/ This is part of an overall study to develop and demonstrate methodologies for estimating the long-term supply and demand for enlisted military manpower, presented in terms of aptitude categories.

4/ TR-8217-2, Aptitude Content of the Non-Prior Service Youth and Enlisted Apprentice Populations: 1982-2010, Management Consulting & Research, Inc., Falls Church, Virginia, 30 September 1983.

5/ A complete description of Aptitude Clusters is contained in the MCR report TR-8217-2 referenced above. An overview of the cluster concept is contained in Appendix A.

Black Hawk helicopters. These demonstrations are intended to address the ability of analysts and designers to evaluate the impact on manpower requirements of different technologies. The AH-64 was chosen to represent a high technology system; the UH-60A was chosen as the counterpart low technology system.

This report documents MCR's application of EMREM on both the AH-64 Apache and UH-60A Black Hawk helicopters. In applying the methodology, we have attempted to use only data that were available in the early stages (i.e., Pre-DSARC Milestone I) of both weapon system acquisitions. A true test of the methodology would have been achieved if all the data used were prior to 1972, the end of the respective AH-64 and UH-60A Concept Exploration Phases. However, because the complete historical files on both systems are unavailable, certain concessions were made in this demonstration of EMREM. The result is a demonstration of the methodology as it could have been performed later in the respective acquisition cycles. However, if the historical record were intact, a "Concept Exploration Phase estimate" of the manpower requirements for both weapon systems could have been made using EMREM. The larger goal of demonstrating early technology implications on manpower requirements has been achieved.

B. ORGANIZATION OF THIS REPORT

Section II of this report provides an overview of the EMREM methodology developed by MCR.[6/] Also included in that section is

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6/ A more detailed description of the methodology and considerations relating to its use are contained in the MCR report documenting the first task in Phase I of the study: TR-8217-3, Demonstration of the Early-On Manpower Requirements Estimation Methodology: M1 Abrams Main Battle Tank, referenced above.

a brief discussion of the data available and appropriate for use in these demonstrations.

Sections III and IV document the EMREM analyses for the AH-64 and UH-60A helicopters, respectively. These two sections parallel each other and are structured according to the parts of the EMREM. Included in each are summaries of the hardware characterization for the new systems, a discussion of the possible baseline systems, and a description of the new system in terms of the appropriate baseline system/subsystem characteristics. The actual development of manpower requirements estimates starting with the identification and collection of relevant data, and ending with the calculation of the estimate and the translation of the estimate to Aptitude Cluster requirements, are also briefly described.

Overall conclusions regarding this demonstration of EMREM are presented in Section V.

Following these sections is a set of appendices which provide additional technical information and document the references used in this analysis.

II. AN OVERVIEW OF THE EARLY-ON MANPOWER REQUIREMENTS ESTIMATION METHODOLOGY

This section describes the basic structure of MCR's Early-on Manpower Requirements Estimation Methodology (EMREM). This discussion concentrates on the structure of the methodology, the sources of data needed to implement the methodology on Army systems, and the data available for use in the current demonstrations.

A. STRUCTURE OF THE METHODOLOGY

The structure of the proposed manpower demand projection methodology is illustrated in Exhibit II-1. There are two major parts to the methodology, comprising a sequence of six analytical steps. These are:

Part 1. Hardware Characterization

- a. Identify Baseline Weapon System
- b. Determine Baseline Weapon System Characteristics Changes
- c. Develop New Weapon System Description

Part 2. Manpower Requirements Estimation

- a. Identify and Collect data on Manpower and Planned System Applications
- b. Develop Manpower Estimates for New Weapon System
- c. Translate Requirements into Aptitude Clusters

A brief description of the methodology is provided below.

1. Hardware Characterization

The first part of the MCR methodology focuses on the identification of the hardware characteristics of the "new" system. By "new", we mean a weapon system concept that is being considered for acquisition and is the focus of the new design

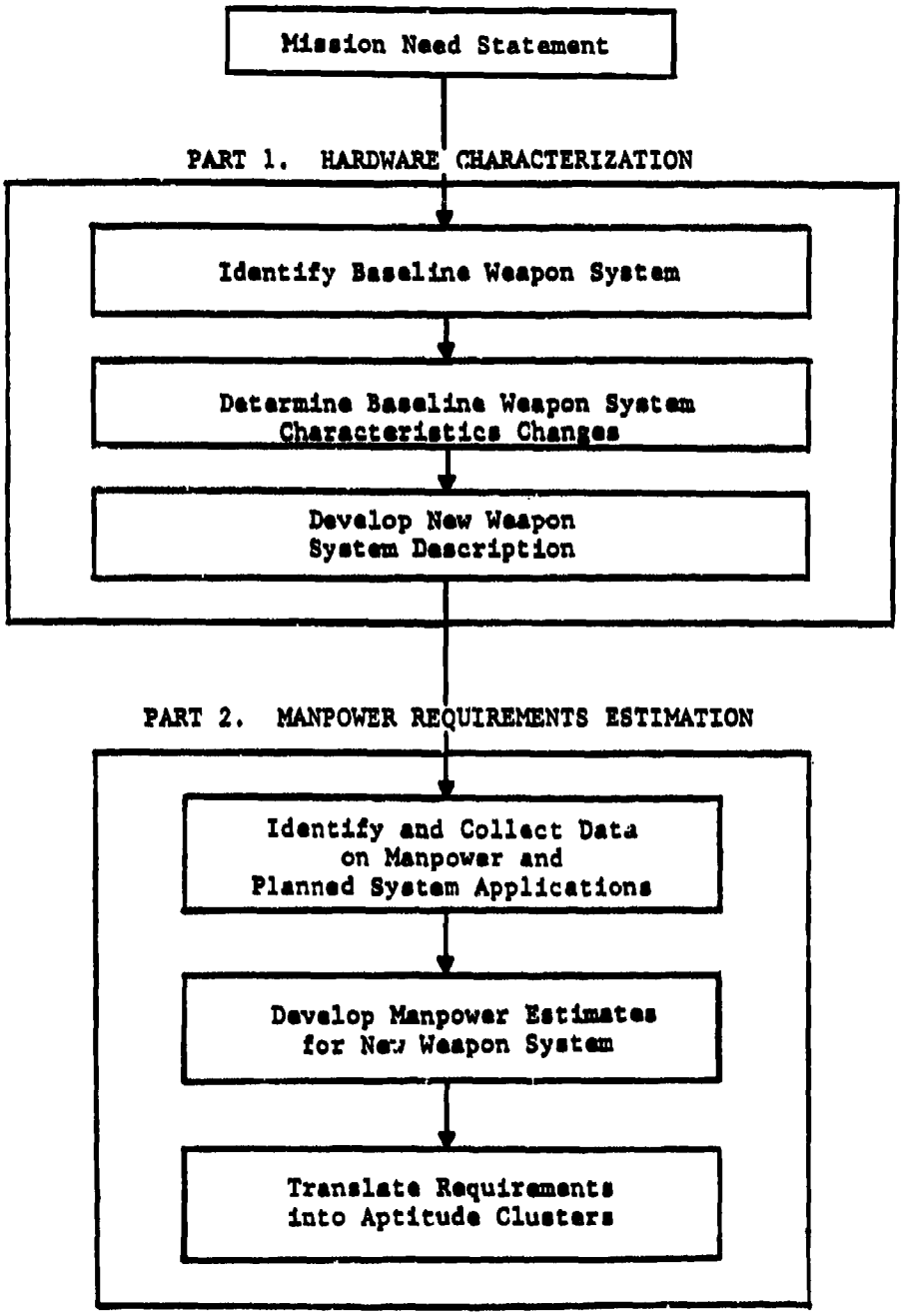

Exhibit II-1. SUMMARY OF THE EARLY-ON MANPOWER REQUIREMENTS ESTIMATION METHODOLOGY (EMREM)

effort. The system may be required to face a completely new threat, replace an existing system or systems, or to exploit emerging technology. The need for this system is presented in its mission need statement.

As with the estimation of manpower requirements, the hardware characterization for the new system relies on comparability analysis. Planned characteristics for the new system are compared to characteristics of existing systems, with each subsystem examined largely independently. Most resource analysis early in the development of a weapon system design uses this approach to some extent. Current OSD policy in the form of MIL-STD-1388-1A, Logistic Support Analysis (April 1983), advocates the use of comparability analysis in developing early resource requirement estimates.

a. Identify the Baseline Weapon System

The baseline system[7/] is that system (or systems) already in the force structure which most closely relates to the design, performance, and support characteristics of the new system. That system is, in effect, the baseline from which new designs or concepts are evaluated.

The purpose of the baseline system is to establish a starting point for considering hardware characteristics and manpower data that may be extrapolated to the new system. In determining the baseline system, the objective is to achieve the

7/ The reference to a single baseline system is made only to simplify the discussion. In actual practice, several systems or portions of several systems, representing specific capabilities required of the new system may be used. In this application of EMREM to the AH-64 and UH-60A both primary and secondary baseline systems are used for this purpose.

most detailed description of performance parameters and hardware characteristics that can be developed from the mission need statement. This allows greater confidence in using the baseline system manpower requirements as an analog for establishing the new system manpower estimates.

b. Determine the Baseline Weapon System Characteristics Changes

Having identified the primary and any secondary baseline systems, which are to serve as the principal source of historical hardware and manpower data, it is important to isolate the elements of the baseline system that are shared with the new system. The basic approach taken in analyzing potential differences between the new and existing systems is to identify those hardware features of the baseline system that are inconsistent with the postulated mission need. These subsystems will be used as the basis for exploring the appropriateness of related manpower requirements in the development of the new system manpower estimate.

c. Develop New Weapon System Description

Having identified those characteristics of the baseline system that can be considered functionally similar to (or wholly in common with) the new system, the next step is to complete the hardware characteristics definition of the new system. That involves completing the list of new system subsystems and identifying subsystem functions that appear to require new or modified hardware.

It is possible that one or more of the new system requirements may have no functional relationship with any existing system or subsystem. These requirements can be classified as developmental, in that no baseline or in-service system data is available for any functional hardware. In these instances, a proxy for the system characteristic could be selected based on the perceived similarity of manpower requirements, or additional analysis supplementing the main estimating effort could be performed to develop preliminary estimates for individual developmental subsystems. In any case, the historical data ultimately used may require tailoring to "fit" the new system. Information concerning the definition of the new system hardware characteristics and the relationship of these to in-service and developmental subsystems usually comes from system designers or other specialists.

The ultimate product of the first part of the EMREM methodology, the Hardward Characterization, is a description of the new system. This description is provided as a list of the set of subsystems contained in the system, associated with a general description of the performance parameters and operational requirements contained in the mission need statement.

The list of hardware characteristics developed in this part of the EMREM methodology acts as the guide for developing the manpower estimates in the next part of the analysis.

2. Manpower Requirements Estimation

The analysis as developed thus far lays the groundwork for developing an initial estimate of weapon system manpower

requirements. For the purposes of this analysis, this involves determining the total number of enlisted operators (or crew) and enlisted below-depot-level maintenance personnel required by the system. It is presented in the context of the organizational unit in which the system will be deployed.

The manpower estimate is developed in three steps, each of which is outlined below.

a. Identify and Collect Data on Manpower and Planned System Applications

In order to develop estimates of manpower requirements, a variety of data must be identified. Information on the planned operational environment, the general structure of the organizational unit, the number of systems to be assigned to organizational units, maintainability and repairability goals, and actual manpower data must be collected. The methodology largely relies on the use of historical manpower data for the baseline system for estimating maintenance manpower requirements. While estimates developed later in the design process can use planned system operational data to develop new system requirements estimates, very early manpower estimating must rely on adapting historical experience to the new application. (The reconstruction of an historical data file no longer intact presents additional concerns which are discussed later in this section.)

b. Develop Manpower Estimates for the New Weapon System

The hardware characterization developed for the

new weapon system forms the basis for subsequently developing estimates of manpower requirements for that system. As explained in the discussion of the hardware characterization, the subsystems planned for the new system are related to those of the primary and secondary baseline systems. Subsystem functions common to both the new and baseline systems are identified after comparing the functional requirements (i.e., planned operational environment, usage rates, maintenance philosophy) of the new system to the baseline. Those subsystems not found to be similar to baseline subsystems are compared to other in-service systems. This analysis expands on the hardware characterization for the purpose of identifying the availability and appropriateness of historical manpower data. Ideally data should be in the form of maintenance manhours per operational hour or increment (e.g., flying hour, mile, etc.) or in a form which can be converted to this type of data for each subsystem. The historical manpower data adapted from the baselines will be used as the basis for developing subsystem manpower "modules" for the new system in the same way that hardware characteristic groups are developed in the first part of the methodology. There may, of course, be elements of the new system that have no direct analog in already operational equipment. A proxy for those functions must be identified from the set of subsystems actually in the force structure in order to maximize (if possible) the use of historical manpower data.

The maintenance manpower requirements experience associated with those subsystems common to both the baseline and

new weapon systems is discerned by examining the historical (actual) data on the baseline system. For those in-service subsystems, a similar approach is used. Attributable manpower requirements can be obtained by extrapolating from other weapon systems the maintenance experience peculiar to the new features.

Using the historical and derived manpower for each of the subsystems, an aggregate estimate of total enlisted below-depot-level maintenance and operator/crew manhour requirements is initially developed and then aggregated to manpower requirements. These manhour and manpower estimates are developed in terms of requirements for specific enlisted military occupations. In order to represent potential uncertainty in these estimates, ranges of requirements are generated. This is accomplished by changing the various input data, usually the usage rate (number of flying hours per year, in the case of the AH-64 and UH-60A helicopters). When possible, peacetime and wartime estimates have been developed by subsystem/occupation in order to demonstrate this capability (currently required in MIL-STD-1388-1A).

c. Translate Requirements into Aptitude Clusters

Having developed the set of new weapon system manpower estimates, the final step in the EMREM process is the translation of those estimates from military occupations to Aptitude Cluster requirements. The purpose of this step is to present the requirements in terms compatible with MCR's proposed supply projection methodology. The Aptitude Clusters represent

the aggregation of Service aptitude composites into a single set of seven groupings. The aptitude composites represent the capabilities the Services have determined to be most closely associated with their particular occupations. The definitions of the Aptitude Clusters are summarized in Appendix A.

B. EXAMINATION OF MANPOWER DOCUMENTS USED IN EMREM

As mentioned above, this demonstration of EMREM is meant to test its use on both high and low technology systems. For this demonstration, the AH-64 was selected as the high technology system while the UH-60A represents the low technology system. This section presents an overview of the documents that are prepared for Army weapon systems along with a discussion of the documents used in these EMREM applications.

Exhibit II-2 summarizes the documents and document types that are prepared for Army weapon systems. Note that the documents have been grouped into three categories:

- regularly generated or standard documents,
- programmatic documents, and
- special studies.

The distinguishing criterion among these three document types is the consistency or uniformity of the data contained in the reports categorized.

As used here, the term "standard documents" refers to those documents prepared on a regular basis for Army weapon systems. They have contents that are of a substantially uniform nature

CONTENTS / DOCUMENTS		LEVEL OF DETAIL						DATA					
		HARDWARE		MANPOWER DATA				DATA ELEMENTS				TYPE	
		Subsystem	Component	MOS	ORG	DS	GS	ANNUAL MAINT. MANHOURS	PERSON-NEL	MEAN TIME BETWEEN FAILURE	MEAN TIME TO REPAIR	ACTUAL	PREDICTED
STANDARD DOCUMENTS	COPPRI			X	X	X		X					X
	MACRIT	X		X	X	X	X	X				X	X
	TOE			X	X				X			X	X
	AMIM			X	X	X		X				X	X
DOCUMENTS	SDC	X		X	X	X		X				X	
	DT Reports			(Contents	Vary)					(Contents	Vary)		
	OT Reports			(Contents	Vary)					(Contents	Vary)		
SPECIAL STUDIES	MAINTAIN-ABILITY PROGRAM PLANS	X	X		X	X	X			X	X		X
	SPECIAL/TASK FORCE REPORTS	X			X	X	X	X					X

Exhibit II-2. POTENTIALLY USEFUL ARMY MANPOWER REQUIREMENTS DATA

across weapon systems. It is this group of documents which EMREM is proposed to most heavily utilize. There are four standard documents considered to be potential sources of data for this type of analysis:

- the Qualitative and Quantitative Personnel Requirements Information (QQPRI),
- Manpower Authorization Standards and Criteria (MACRIT),
- Tables of Authorization and Equipment (TOE), and
- Army Modernization Information Memorandum (AMIM).

Programmatic documents are those documents that are typically prepared for Army weapon systems, but have contents that need not be uniform across weapon systems or even across repeated preparations for the same weapon system. Often their contents reflect specially tailored data collection efforts as opposed to a standard data collection. Three types of reports are developed that fall into this category:

- Sample Data Collections (SDC),
- developmental test (DT) reports, and
- operational test (OT) reports.

The final category, special studies, includes documents prepared in response to a specific analytical requirement. Examples of these special studies are task force reports and special cost analyses.

The extent to which any type of data influences the EMREM estimates depends largely on data availability. The ideal set of data for the current application of EMREM (i.e., baseline subsystem

manpower data available before the new system's DSARC Milestone I) is incomplete. Much of the appropriate data, which are known to have been prepared by the Army, are now unobtainable.

The availability of data for this application is discussed at this point in the report because we believe there are inherent problems associated with reconstructing historical data and they have affected this analysis. Application of EMREM on a weapon system currently in concept exploration would not confront these problems since appropriate contemporary data for actual or analog systems should be available or could be developed for the analysis at the time. In normal applications, the analysis of the availability and appropriateness of manpower data would occur after the characterization of the hardware, as part of the development of the manpower estimates.

C. APPROPRIATE DATA FOR THE AH-64 AND UH-60A APPLICATIONS

At this point, the set of potential input data is narrowed down to those actually used in the EMREM calculation. In doing so, the reasons that only some data were suitable as input are explained. The actual data used in this caluclation are included in the EMREM program listing in Appendix A of this report.

Since this is an historical reconstruction, the selection of the documents used in this analysis has been limited to those currently available. Exhibit II-3 outlines the status of document availability for the AH-64, UH-60A, and the respective baseline systems.

	WEAPON SYSTEM					
DOCUMENT	AH-1G	AH-56	AH-64	UH-1H	YUH-60A	UH-60A
QQPRI	UA	UA	NA	UA	NA	UA
MACRIT	X	UA	NA	NA	NA	NA
TOE	X	UA	UA	X	NA	X
AMIM	UA	UA	UA	UA	NA	X
SDC	NA	UA	X	UA	NA	NA
OT	UA	UA	NA	UA	UA	UA
DT	UA	UA	NA	UA	UA	UA
Maintainability Program Plan	UA	UA	NA	UA	X	UA
Task Force Reports	NA	X	NA	NA	NA	NA

UA = Unavailable data
X = Available and used data
NA = Data not appropriate for use in this study

Exhibit II-3. AVAILABLE MANPOWER REQUIREMENTS DATA: AH-64 and UH-60A

A "UA" denotes that a document may have been prepared for the weapon system, but was unavailable for use in this analysis. An "X" signifies that the referenced report was obtained and appropriate for the current application of EMREM. An "NA" denotes that a document was not appropriate for this EMREM application because of its age (i.e., the document was prepared well after Milestone I for the weapon system) or lack of relevant information.

In this analysis, the intention has been to use pre-DSARC I data exclusively. To the degree possible this has been followed. However, for both the AH-64 and the UH-60A, a full set of circa pre-DSARC I data is no longer available. If a full set of data had been available, then it is doubtful that data for less desirable baseline systems, such as the YUH-60A would have been used. The use of the limited data that are now available for more contemporary systems, such as the UH-1H pre-DSARC I system, was also not considered appropriate in some cases because they did not represent significant technolog-ical similarity with the new systems.

As can be seen from the limited range of data, the selection of the respective baseline systems was based largely on the availability of supporting documents. In the case of the UH-60A analysis, this has significantly influenced the type of analysis which has been done.

In the next section, the EMREM analysis performed on the AH-64 is discussed.

III. EMREM APPLICATION: AH-64 APACHE HELICOPTER

Having completed an overview of EMREM, we now discuss its application to the Army's Advanced Attack Helicopter, the AH-64 Apache. The AH-64 is a twin-engine, four-bladed helicopter operated by a tandem-seated crew of two. The pilot is located in the rear cockpit, with the copilot/gunner occupying the forward position. The AH-64 is the first Army Attack Helicopter to be developed specifically for day, night, and adverse weather operations. Its missions include anti-armor, covering force, flank security, economy of force, and airmobile escort. The AH-64, which is being built by Hughes Helicopters, is tentatively scheduled for fielding in February 1984.

The discussion of the EMREM application to the AH-64 is presented in two main parts, the Hardware Characterization and Manpower Requirements Estimation.

A. HARDWARE CHARACTERIZATION

The Hardware Characterization of the AH-64 is described below in terms of the following three steps of Part 1 of EMREM:

1. Identify Baseline Weapon System,
2. Determine Baseline Weapon System Changes, and
3. Develop New Weapon System Description.

Each of these is described below.

1. Identify Baseline Weapon System

As discussed in the last section, the baseline system is used to establish a starting point for considering hardware

characterization and manpower requirements data that may be applied to the new system undergoing study. In determining the baseline system or systems, the objective is to achieve the most detailed description of performance parameters and hardware characterisitics available. This allows greater confidence in using the baseline system manpower requirements to establish manpower estimates for the new system.

For the AH-64, MCR chose primary and secondary baseline systems. The primary baseline system represents the existing system which most closely resembles the proposed new system (the AH-64). The primary baseline system provides a generic description of hardware information and specific engineering and manpower data. The secondary baseline system provides additional information on those systems not currently found on the baseline system but expected to be on the new system.[8/] In addition, the primary and secondary baseline systems are chosen based on their relationship to the DSARC Milestone I date of the new system, in this case September 1972. Ideally, the baseline weapon system should have been fielded before the initiation of Concept Exploration for the new system.

Exhibit III-1 illustrates the evolution of U.S. attack helicopters. For this demonstration of EMREM, the primary baseline system chosen for the AH-64 is the AH-56 Cheyenne helicopter. The secondary baseline system is the AH-1G Huey Cobra. As can be

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8/ In general, more than one secondary baseline may be chosen. In fact, the secondary systems may be from a completely different class of weapon system than the new system.

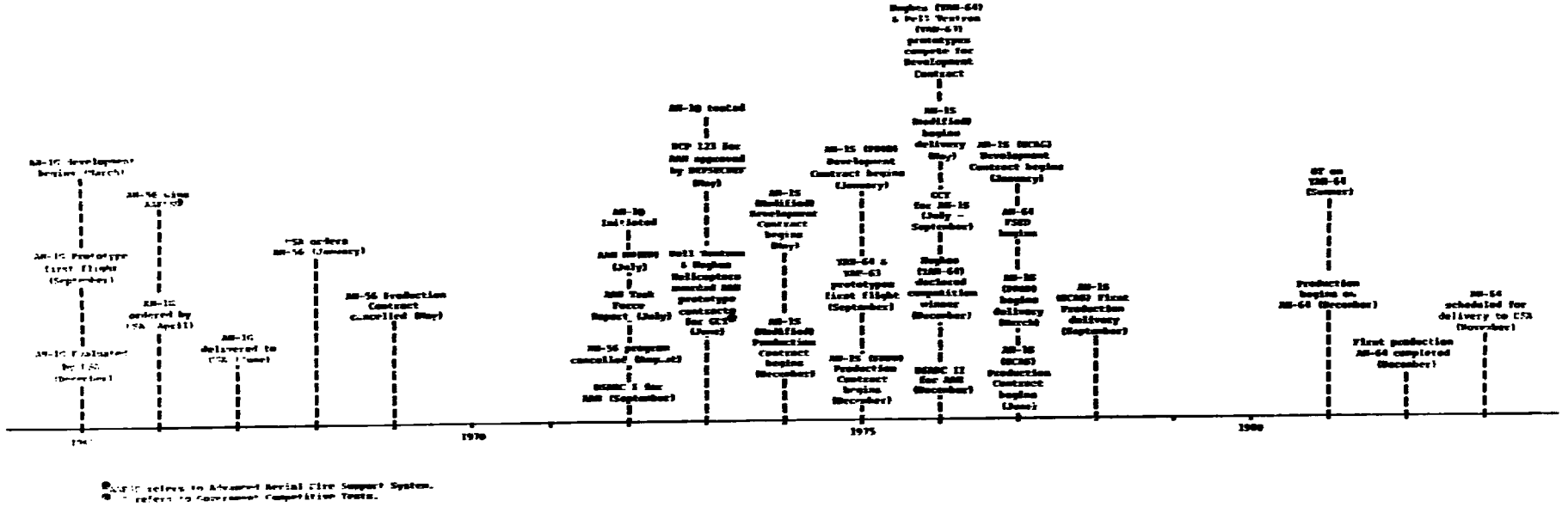

Exhibit III-1. EVOLUTION OF U.S. ATTACK HELICOPTERS SINCE 1965.

seen in this time line, these are the only two systems available before the DSARC I Milestone of the AH-64.

While the baseline systems may not completely represent all the characteristics to be embodied in the new system, they do present the best starting point from which to identify hardware and manpower characteristics the new system will possess. Due to the lack of new system detail available in the Concept Exploration Phase, the modular approach implemented by EMREM identifies the best approximation of the new system.

2. Determine Baseline Weapon System Changes

Having identified the baseline systems, which serve as the principal source of historical hardware and manpower requirements data, it is important to isolate the elements of those baseline systems that are or are not shared with the new system. In applying EMREM, the basic approach taken in analyzing the differences between the new and baseline systems is to consider the similarity of their hardware characteristics and performance requirements. Much information is provided in the new system mission need statement. The primary baseline system, in its function as a starting point for describing the new system, is largely considered in terms of specifically non-transferrable characteristics, i.e., subsystems it will not have in common with the new system. The secondary baselines act as sources to provide these "missing" data.

The subsystems requiring substitutions were identified by MCR through the use of an aggregate work breakdown structure

(WBS). The WBS used here has been developed by modifying the fixed-wing aircraft WBS, since there is no generally accepted WBS for helicopters. Exhibit III-2 indicates the 10 functional subsystems identified and used in this EMREM demonstration.

As indicated earlier, the major source of descriptive hardware information available at the Concept Exploration Phase is the mission need statement. This document outlines the performance parameters and hardware features required of the new system. The subsystems requiring substitution were identified by MCR by comparing the performance and design parameters of the baseline weapon systems. As a result, MCR chose all but three subsystems from the AH-56, as representative of subsystems to be found on the new system. The AH-1G was used as the source for two of the other subsystems, hydraulics/utilities and electrical systems, based on analysis of the mission need requirements. The tenth subsystem, the vehicle power plant, was not selected from either of the two baseline systems since it was a newly developed system. Exhibit III-3 specifies the AH-64 baseline subsystems chosen for this analysis.

The vehicle power plant used in this analysis was the one originally selected by the Army in December 1971 for use in both the AH-64 and the new utility tactical transport aircraft system (UTTAS) YUH-60A, a prototype of the UH-60A. This is the GE-T700 ungeared, free turbine, turbo shaft engine. There are a number of reasons why these two aircraft, although designed for significantly different missions, would have the same engine. The AH-64 and UH-60A are intended to be deployed together and early

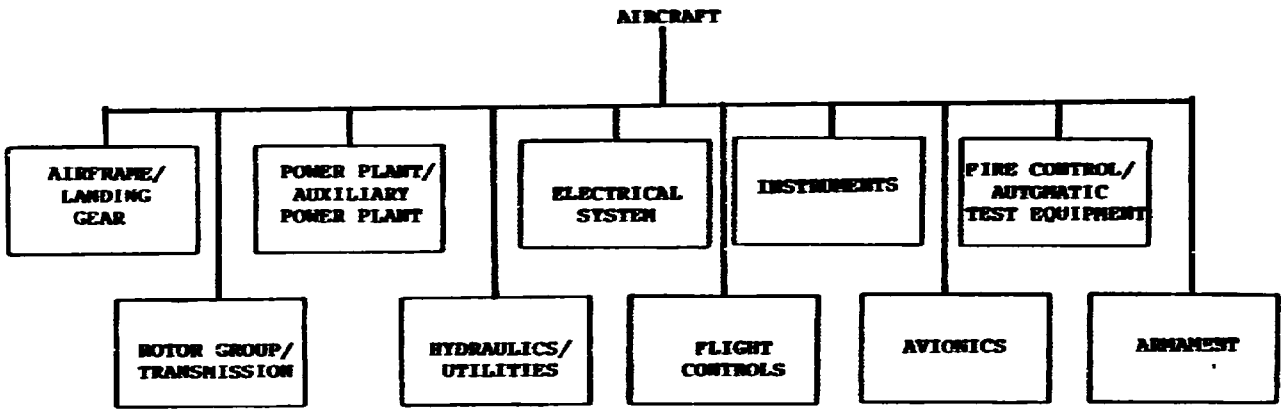

Exhibit III-2. MCR-ORIGINATED HELICOPTER WBS

SUBSYSTEM	BASELINE SYSTEM
Airframe/Landing Gear	AH-56
Rotor Group/Transmission	AH-56
Power Plant/Auxiliary Power Plant	YUH-60A
Hydraulics/Utilities	AH-1G
Electrical System	AH-1G
Flight Controls	AH-56
Instruments	AH-56
Avionics	AH-56
Fire Control/Automatic Test Equipment	AH-56
Armament	AH-56

Exhibit III-3. AH-64 BASELINE SUBSYSTEM SELECTION

planning for both systems advocated compatability between the two aircraft. Also, in keeping with the Army's modular approach for aviation maintenance, having similar engines on aircraft which are deployed together should enable a more efficient and effective use of maintenance resources. In addition, it was clearly possible to plan for such commonality since the development of the two systems were chronologically related. As can be seen in the development timeline for the AH-64 (Exhibit III-1) as well as the corresponding one for the UH-60A, the AH-64 DSARC I occurred in September 1972, while the mission need for the UH-60A was issued slightly earlier, in February 1972. The UH-60A mission need statement indicated the Army's intention of having the AH-64 engine used on the UH-60A as it became available. The transferrance of technology developed on one system (even if that system is not produced) to later systems is not unusual in helicopter development, as will be seen in the discussion of the UH-60A.

The baseline subsystems discussed in this section are used in the next section to formulate the new weapon system description.

3. Develop New Weapon System Description

As noted in the discussion of the WBS used in this analysis, 10 subsystems were identified as representing the major hardware groups on a generic helicopter, with elements such as armament being more mission specific. In the preceeding steps, analogs for each of these subsystems were identified, to be used as representative of hardware and performance characteristics for

the new system. As noted earlier, all but one of the subsystems were selected from the two baselines, with the exception being the vehicle power plant, which was a newly developed system.

Having identified tentative selections for each of the generic subsystems, in this step the hardware characterization for the new system is refined. This largely entails a more detailed review and reevaluation of the preceeding comparability analysis, with a view towards identifying any concerns which must be noted in using the manpower data related to these baseline subsystems.

Taken together these 10 subsystems provide the best possible functional description (based solely on the mission need statement) of the Advanced Attack Helicopter. The justification for choosing each of the subsystems is reviewed below:

- The AH-56 airframe was chosen because its silhouette most closely resembles the silhouette of the proposed AH-64. Since the size of the silhouette has a negligible effect on maintenance requirements, the AH-56 airframe provides the best description of the proposed airframe of the new system. The AH-56 landing gear was selected based on a specification in the mission need statement for wheeled, as opposed to the non-retractable, tubular, skid-type landing gear. During the Concept Exploration Phase for the AH-64, only the wheeled landing gear of the AH-56 fulfilled this requirement.

- The AH-56 rotor group, which includes the transmission, was selected based on statements in the mission need requiring the AH-64 to employ the most advanced technology feasible. During the Concept Exploration Phase the AH-56 rotor group represented this advanced technology.

- The selection of the YUH-60A GE-T700 power plant was addressed earlier.

- The hydraulics/utilities and electrical system were chosen from the AH-1G. Information contained in the mission need statement did not identify required changes to these subsystems.

- The AH-56 flight controls, instruments and avionics were selected since they most closely satisfy the performance specifications outlined in the mission need statement.

- The fire control and automatic test equipment were chosen from the AH-56. The AH-56 includes such hardware features as an automatic stabilization system, laser range-finder, helmet sighting system and a fire control computer, all of which were specified in the mission need statement.

- The armament selected from the AH-56 are its Point Target Weapon Subsystem, Area Weapon Subsystem, and Aerial Rocket Subsystem. These most closely resemble those postulated in the mission need statement for the AH-64.

Based on the selection of these subsystems, we next examined the availability of manpower data which could be used in developing the manpower requirements estimates.

B. AH-64 EMREM MANPOWER REQUIREMENTS ESTIMATION

The development of the manpower estimate for the AH-64 was based on the application of baseline subsystem requirements data to the new system operational characteristics. Allocations of manpower are made for the organizational units and relevant portions of the intermediate maintenance units. The organizational unit used for this purpose is the Air Cavalry Squadron of an Air Assault Division. Consideration of operator personnel (pilot and co-pilot/gunner) are excluded from this analysis because those positions are filled by officers or warrant officers, and, in this application of EMREM, we are only concerned with enlisted

personnel requirements. The manpower requirements estimation process is discussed in three parts:

1. Identify and Collect Data,
2. Develop Manpower Requirements Estimates, and
3. Translate Requirements Into Aptitude Clusters.

Each of these steps is discussed below.

1. Identify and Collect Data

As mentioned earlier, the availability of applicable manpower requirements data significantly impacted this analysis. Since this demonstration of EMREM involved an historical reconstruction of data, the use of particular documents was determined by their current availability. Much of the relevant manpower data (for the baseline systems) that were documented prior to Milestone I for the AH-64 are currently unavailable.

An original intention of the EMREM was to be able to estimate manpower requirements for the different phases of the system's life cycle (i.e., initial deployment, steady state and post production). In the first application of EMREM to an Army system, the M1 Abrams Main Battle Tank, insufficient data was found to support any but steady-state-type estimates. Research into the availability of data to support the AH-64 (as well as the UH-60A) EMREM analysis has produced no suitable data to support the full life cycle analysis that might have been done before the system's DSARC Milestone I. For this reason, only a steady-state-type analysis, more closely related to the type of

estimate represented in Army staffing documents, has been possible for the AH-64.

The data used in the AH-64 EMREM application came from three sources, as noted in Exhibit III-4. Again, the sources of data are limited due to an inability to reconstruct the complete historical data file available in 1972. These sources were found to be the only ones suitable for use in this analysis. Specifically, subsystem-level data on maintenance manhours per flying hour (MMH/FH) one of the critical data types for EMREM analysis were obtained from each of these sources and were used as EMREM input data. In calculating manpower requirements estimates, the EMREM progam documented in Appendix B uses, in addition to MMH/FH, the size of the organizational unit and planned annual usage rates. Both of these parameters are addressed in detail in the following discussion.

2. Develop Manpower Requirements Estimates

In order to actually calculate the manpower requirements estimates, specific data must be extracted from the source documents. The data are used to calculate the manhours required by each subsystem in terms of the military occupations which work on the subsystem, and then translated into numbers of individuals required in each of these enlisted occupations. This is accomplished by performing the following six steps:

- relate the baseline subsystems developed in the hardware characterization to their associated maintenance Military Occupational Specialty (MOS);
- determine the size of the organizational unit in which the new system is to be deployed;

SUBSYSTEM	BASELINE SYSTEM	MANPOWER DOCUMENT USED
Airframe/Landing Gear	AH-56	AAH TF Report[1/]
Rotor Group/Transmission	AH-56	AAH TF Report
Power Plant/Auxiliary Power Plant	YUH-60A	Sikorsky YUH-60A Aircraft Maintainability Prediction Report
Hydraulics/Utilities	AH-1G	AR570-2, Change 3
Electrical System	AH-1G	AR570-2, Change 3
Flight Controls	AH-56	AAH TF Report
Instruments	AH-56	AAH TF Report
Avionics	AH-56	AAH TF Report
Fire Control/Automatic Test Equipment	AH-56	AAH TF Report
Armament	AH-56	AAH TF Report

1/ AAH TF Report refers to the Advanced Attack Helicopter Task Force Reports.

Exhibit III-4. FINAL BASELINE SUBSYSTEM SELECTION AND SOURCES OF MANPOWER DATA: AH-64

- determine applicable peacetime and wartime usage rates;
- calculate maintenance manpower requirements and allocate to appropriate maintenance echelons;
- convert maintenance manhour requirements to personnel requirements; and
- display manpower requirements estimates for peacetime and wartime scenarios.

Each of these steps is discussed below.

a. Relate Baseline Subsystems to Associated Maintenance MOS

The manpower requirements estimate developed using EMREM is ultimately to be translated into Aptitude Clusters. Therefore, at some point, the manpower requirements must be grouped according to related skills. It is simpler to relate the hardware characteristics (i.e., subsystems) to the occupations of the manpower maintaining the subsystem from the outset rather than to convert to Army Military Occupational Specialty (MOS) code in the final stages of the analysis. Since, the latter categories may be readily related to skills, we have opted to take this approach.

Exhibit III-5 shows the results of the association of the AH-64 hardware characterization, (by WBS subsystem), with occupations and related MOS. For the MOS which were not indicated explicitly as subsystem specific, such as Advanced Attack Helicopter Repairer (referred to as Technical Inspectors in the more senior pay grades) the relevant MOS was deduced from AR 611-201. In addition to those MOS identified in this analysis, a new MOS for the Integrated Helmet and Display Sighting System, with skills similar to those of a 43M Fabric Repair Specialist,

MOS	OCCUPATION TITLE[1/]	RELATED HARDWARE CHARACTERISTIC
35	Avionic Mechanic[2/]	Flight Controls/Instruments/Avionic
67R[3/]	Attack Helicopter Repairer	Various Subsystems/Inspection
68B	Aircraft Power Plant Repairer	Power Plant/Auxiliary Power Unit
68D	Aircraft Power Train Repairer	Rotor Group/Transmission
68F	Aircraft Electrician	Electrical System
68G	Aircraft Structural Repairer	Airframe/Landing Gear
68H	Aircraft Pneudraulics Repairer	Hydraulics/Utilities
68J	Helicopter Missile System Repairer	Fire Control/Automatic Test Equipment
68J/M[4/]	Helicopter Weapons System Repairer	Armament

1/ The occupation titles and MOS codes have been taken from AR611-201.

2/ This is a generic term referring to all the relevant avionic maintenance required on the AH-64.

3/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

4/ These MOS have been combined since both work on the Armament.

Exhibit III-5. RELATIONSHIP OF MOS TO HARDWARE CHARACTERISTICS: AH-64

is currently being developed. As can be seen in Exhibit III-5, there are instances where multiple maintenance or support functions of several subsystems were identified with a single MOS. In those cases, individual requirements for the MOS for each subsystem were calculated and added together. A particular instance of this is the 35 Avionic Mechanic, who works on the flight control instruments and avionics systems. Requirements for individual MOS have been grouped into a single non-system-specific MOS group of 35.

b. Determine AH-64 Organisational Unit Size

In the change from the H-series Table of Organization and Equipment (TOE), which only included AH-1 Series data, to J-series TOEs (under which the AH-64 will be fielded), the number of helicopters per squadron decreased from 27 to 18. This is a doctrinal change that could not have been predicted during Concept Exploration Phase for the AH-64. Although this violates the intention of developing a "pure" Concept Exploration Phase estimate, the 18-helicopter squadron was used here as the organizational unit for the manpower requirements estimates in order to facilitate comparison to current Army estimates. Had the 27-helicopter squadron been used, the maintenance manhour estimates developed here would have been significantly larger.

c. Determine Applicable Peacetime and Wartime Usage Rates

For this application of EMREM, two usage rates have been specified. One reflects a peacetime scenario, the

other reflects expected wartime operations. The wartime usage rate is based on information in the mission need statement. A usage rate range of 1200-1320 flying hours/year (FH/Yr) reflects the various operating tempos of a wartime environment. The peacetime usage rate of 240 FH/Yr is based on information obtained from the Department of the Army and is indicative of peacetime operating tempos. In the sections that follow, the EMREM estimates are developed as a function of these usage rates.

d. Calculate Manpower Requirements by Maintenance Level

As cited earlier, the manpower data must be arrayed into the appropriate echelons of maintenance. In the case of Army aviation, organizational (ORG), direct support (DS), and general support (GS) maintenance are now organized into Aviation Unit Maintenance (AVUM) and Aviation Intermediate Maintenance (AVIM). This is the result of the aggregation of ORG and some proportion of DS maintenance to form the AVUM echelon, and the combining of the remaining proportion of DS with GS to form the AVIM echelon. However, this change was made in the mid-1970s, and so the aviation maintenance data from 1972 refers only to ORG, DS and GS maintenance echelons. Again, this is a doctrinal change which could not have been predicted during the Concept Exploration Phase of the AH-64.

In this study, manhour requirements are calculated for each echelon of maintenance, ORG, DS, and GS. As shown in Exhibits III-6 to III-8 the estimates are presented by MOS for both peactime and wartime scenarios for an organizational unit of

MOS / FH/YR	EMREM ESTIMATE[1/] PEACETIME 240	WARTIME 1200-1320	BASELINE SYSTEM
35	2717	13586-14945	AH-56
67R[2/]	3512	17561-19317	AH-56
68B	364	1822-2004	YUH-60A
68D	1512	7560-8316	AH-56
68F	0	0-0	AH-1G
68G	138	691-760	AH-56
68H	0	0-0	AH-1G
68J	164	821-903	AH-56
68J/M	13224	66118-72729	AH-56
TOTAL	21631	108159-118974	

1/ Estimate is for 18 AH-64 helicopters.

2/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

Exhibit III-6. AH-64 ORG LEVEL ANNUAL MAINTENANCE MANHOUR ESTIMATE

MOS / MH/Yr	EMREM ESTIMATE[1] PEACETIME 240	WARTIME 1200-1320	BASELINE SYSTEM
35	2013	10066-11072	AH-56
67R[2]	959	4785-5275	AH-56
68B	316	1578-1736	YUH-60A
68D	9621	48103-52914	AH-56
68F	8640	43200-47520	AH-1G
68G	298	1480-1639	AH-56
68H	3024	15120-16632	AH-1G
68J	583	2916-3208	AH-56
68J/H	2363	11815-12997	AH-56
TOTAL	27817	139083-152993	-----

1/ Estimate is for 18 AH-64 helicopters.

2/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

Exhibit III-7. AH-64 DS LEVEL ANNUAL MAINTENANCE MANHOUR ESTIMATE

MOS / MH/Yr	MANHOUR ESTIMATE[1] PEACETIME 240	WARTIME 1200-1320	BASELINE SYSTEM
35	6070	30348-33383	AH-56
67R[2]	0	0-0	AH-56
68B	0	1-1	YUH-60A
68D	199	994-1093	AH-56
68F	7776	38880-42768	AH-1G
68G	52	259-285	AH-56
68H	3888	19440-21384	AH-1G
68J	877	4385-4823	AH-56
68J/M	3218	16092-17701	AH-56
TOTAL	22080	110399-121438	-----

1/ Estimate is for 18 AH-64 helicopters.

2/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

Exhibit III-8. AH-64 GS LEVEL ANNUAL MAINTENANCE MANHOUR ESTIMATE

18 AH-64s. The baseline system is also indicated. The total of the annual maintenance manhours across MOS provides an aggregate picture of the maintenance intensity associated with each echelon of maintenance. As an example, it is evident that the majority of armament and fire control/automatic test equipment repair performed by 68J/M is at the ORG echelon. This suggests that rapid turnaround is required for the armament and fire control components. The absence of 68F and 68H maintenance requirements at the ORG echelon is a result of the specification in AR 570-2 (Change 3, dated May 1971), the source of AH-1G manpower data. According to AR 570-2 (Change 3), maintenance performed by MOS 68F and 68H is deferred to the DS to GS echelons

Exhibit III-9 shows the total annual maintenance manhours required across ORG, DS and GS maintenance echelons by MOS. The next section describes the conversion from manhours to the number of personnel required.

c. Convert Manhours to Personnel

The conversion of manhours to numbers of personnel is accomplished by dividing annual manhour requirements by average available productive manhour (AAPMH) factors that are described in AR 570-2. Those factors reflect the estimated number of hours per year available for productive work by the individuals engaged in particular types of maintenance. For calculations for each echelon, the EMREM program uses a range of AAPMH factors as input.

MOS / MH/Yr	EMREM ESTIMATE[1/] PEACETIME 240	WARTIME 1200-1320	BASELINE SYSTEM
35	10800	54000-59400	AH-56
67R[2/]	4471	22356-24592	AH-56
68B	680	3401-3741	YUH-60A
68D	11332	56657-62323	AH-56
68F	16416	82080-90288	AH-1G
68G	488	2440-2684	AH-56
68H	6912	34560-38016	AH-1G
68J	1624	8122-8934	AH-56
68J/M	18805	94025-103427	AH-56
TOTAL	71528	357641-393405	-----

1/ Estimate is for 18 AH-64 helicopters.

2/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

Exhibit III-9. AH-64 ORG, DS AND GS LEVEL TOTAL ANNUAL MAINTENANCE MANHOUR ESTIMATE

While the quotient of the manhour requirements and the AAPMH factor need not be a whole number, the personnel authorizations for an organizational unit must be expressed in terms of whole people. Therefore, these quotients must be rounded. A convention has been used in this analysis concerning rounding to the next whole person. Since rounding down always results in greater workloads (per man), explicit consideration was given to the situation in which rounding was required.

The criterion used in this study in applying the rounding rule has been that if rounding down means more than ten percent more work per year, per man, then rounding upward is to be done. However, use of this rule was modified in that if satisfaction of the former condition implies that personnel involved are each working at less than 90 percent of the AAPMH factor, then rounding downward prevails. This latter stipulation prevents over-estimation of personnel requirements. This convention was used rather than simply rounding to the nearest integer, since it allows for the more explicit balancing of workload. For further details on these calculations, consult Appendix B.

In the Concept Exploration Phase only a tentative estimate of the planned usage rate is available. For this reason and also to reflect various operating scenarios, a range of usage rates was used in this analysis. Regarding the use of a particular AAPMH factor, questions concerning the validity of any one factor value induced the use of a range of AAPMH values as well.

For wartime ORG echelon maintenance and support personnel requirements calculations, the AR 570-2 TOE Category I

AAPMH value of 2500 hours per year, plus and minus 10 percent, was employed. Similarly, DS echelon calculations were based on an AAPMH value of 2700 hours per year (TOE Category II), plus and minus 10 percent. GS echelon calculations were based on a value of 3100 hours per year (TOE Category III), plus and minus 10 percent.

Strictly speaking, practically any of the assumptions that are invoked in the calculation of these manpower requirements estimates could serve as a range-generating basis. For example, the number of helicopters per organizational unit could have been varied. However, varying such key parameters was deliberately restricted in this demonstration so as to avoid obscuring the results.

For further elaboration on the mechanics of the calculations, consult the EMREM computer code located in Appendix B.

f. Display Manpower Requirements Estimates for Peacetime and Wartime Scenarios

Exhibit III-10 summarizes the peacetime personnel requirements at ORG, DS and GS echelons of maintenance. Only one number for personnel is specified since only one value for the AAPMH was used and also only a single usage rate was specified in the mission need statement.

Exhibit III-11 summarizes the wartime personnel requirements at the ORG, DS and GS echelons of maintenance. A range of personnel is generated here due to use of a range of AAPMH factors and usage rates. This exhibit illustrates that in wartime, MOS 68J/M requires the largest personnel allocation at

	EMREM PERSONNEL REQUIREMENTS ESTIMATE 1/			
AAPNH / FH/YF / MOS	ORG 2500 240	DS 2700 240	GS 3100 240	BASELINE SYSTEM
35 2/	1	1	2	AH-56
67R 3/	2	1	0	AH-56
68B	1	1	0	YUH-60A
68D	1	4	0	AH-56
68F	0	3	3	AH-1G
68G	0	1	0	AH-56
68H	0	2	2	AH-1G
68J	0	1	1	AH-56
68J/M 4/	5	1	1	AH-56
TOTAL	10	15	9	-

1/ Estimate is for 18 AH-64 helicopters.

2/ Generic term referring to all relevant avionics maintenance required on the helicopter.

3/ 67R changed to 67Y since AH-64 Concept Exploration Phase.

4/ These MOS have been combined in this analysis since they both work on the Armament and work load can not be differentiated.

Exhibit III-10. AH-64 ORG, DS AND GS LEVEL PEACETIME PERSONNEL REQUIREMENTS

MOS	EMREM PERSONNEL REQUIREMENTS ESTIMATE[1] ORG LOW	ORG HIGH	DS LOW	DS HIGH	GS LOW	GS HIGH	BASELINE SYSTEM
Range AAPMH FH/YE	2250 1200	2750 1320	2430 1200	2970 1320	2790 1200	3410 1320	
35[2]	5	7	4	5	9	11	AH-56
67R[3]	6	8	2	2	0	0	AH-56
68B	1	1	1	1	0	0	YUH-60A
68D	3	4	16	21	1	1	AH-56
68F	0	0	14	19	11	15	AH-56
68G	1	1	1	1	0	1	AH-56
68H	0	0	5	7	6	7	AH-56
68J	1	1	1	2	2	2	AH-56
68J/M[4]	24	32	4	5	5	6	AH-56
TOTAL	41	54	48	63	34	43	-

1/ Estimate is for 18 AH-64 helicopters.

2/ Generic term referring to all relevant avionics maintenance required on the helicopter.

3/ 67R changed to 67Y since AH-64 Concept Exploration Phase.

4/ These MOS have been combined in this analysis since they both work on the Armament and work load can not be differentiated.

Exhibit III-11. AH-64 ORG, DS AND GS LEVEL WARTIME PERSONNEL REQUIREMENTS

the ORG echelon. This could be due in part to the maintenance requirements associated with repair of the HELLFIRE missile system and its related materiel.

With conversion from manhours to personnel complete, we now translate the personnel estimates into Aptitude Clusters.

3. Translate Manpower Requirements to Aptitude Clusters

The final step in the development of the EMREM estimates involves the translation of the manpower requirements estimates by MOS into requirements by Aptitude Clusters. In this demonstration of the methodology, only the ORG apprentice enlisted personnel portion of the requirements estimate was translated. (Apprentice personnel are defined to be those personnel at pay grades E-4 and below, or, equivalently, personnel at skill level 1.) Only ORG apprentice personnel requirements could be mapped into Aptitude Clusters. There are two reasons for this. First, Aptitude Clusters, in their present stage of development, apply only to apprentice enlisted personnel. Second, the translation of the estimates into Aptitude Clusters requires pay grade or skill level information on those MOS groups for which estimates are calculated. There is a lack of pay grade and skill level data at DS and GS levels that would enable the calculation of apprentice requirements by cluster.

The translation of the EMREM estimates (broken out into MOS groups) into Aptitude Clusters is performed in the following two steps:

- determine the requirement for apprentice enlisted personnel, and

- aggregate apprentice personnel requirements into Aptitude Clusters.

a. Determine Apprentice Enlisted Personnel Requirements

None of the documents that provided input data for the AH-64 demonstration of EMREM included pay grade or skill level information. However, inspection of an Air Cavalry Squadron TOE permitted deduction of the pay grade/skill level structure for ORG echelon maintenance and support. The TOE used for this purpose was TOE number 17-95H, dated December 1971. That TOE contains the personnel slots for ORG echelon maintenance and support activities associated with the AH-1G (the only deployed baseline system used in this study). This is a reasonable TOE to use since it was developed prior to the DSARC Milestone I for the AH-64.

The apprentice personnel requirements are extrapolated from the EMREM ORG echelon estimates by:

- summing the personnel slots in the TOE for each MOS group;
- summing the personnel slots at pay grades E-4 and below for each MOS group -- i.e., summing the apprentice positions;
- calculating the ratio of apprentice slots to total number of slots for each MOS group; and
- multiplying the EMREM ORG personnel requirements (for each MOS group) by these ratios and rounding where necessary.

The results of applying these steps to the EMREM ORG level estimates for both peacetime and wartime are summarized in Exhibit III-12. As can be seen in this exhibit it is clear that for both the peacetime and wartime scenarios the majority of ORG level

EMREM PERSONNEL REQUIREMENT ESTIMATE[1/]

MOS[2/]	PEACETIME	WARTIME	
		LOW	HIGH
35	1	3	4
67R[3/]	0	1	2
68B	1	1	1
68D	1	3	4
68F	0	0	0
68G	0	1	1
68H	0	0	0
68J	0	0	0
68J/M	0	0	0

1/ Estimate is for 18 AH-64 helicopters.

2/ Operator personnel are excluded since they are Warrant Officers.

3/ MOS 67R was changed to 67Y after the AH-64 Concept Exploration Phase.

Exhibit III-12. AH-64 ORG LEVEL APPRENTICE MAINTENANCE PERSONNEL

enlisted personnel are not apprentices. The peacetime estimate shows only three of the estimated 10 enlisted personnel being apprentices, while the wartime estimate shows the range being between 9 and 12 apprentices out of a total of 41 to 54 enlisted personnel.

A similar approach for determining pay grade/skill level structure for maintenance personnel at the DS and GS echelons was not feasible because the TOEs containing the slots for maintenance personnel at those echelons are such that identification of AH-1G dedicated personnel is not possible. That is, DS and GS maintenance personnel are deployed into units summarized by TOEs that make it difficult to determine the skill level of MOS groups involved in maintenance of helicopters and no other materiel. In addition, since this is an historical reconstruction, problems associated with data availability were also encountered. Even if we had violated the pure DSARC I criteria by using a J Series TOE, DS and GS personnel still could not be mapped into Aptitude Clusters. This is due to a change in the organization of Army maintenance initiated about 1975. Since then, Army aviation maintenance has been organized into AVUM and AVIM. The AVUM level incorporates the "old" ORG level plus a portion of the DS level. The AVIM level incorporates a portion of the DS level and all of GS. Because of this arrangement, ORG, DS, and GS maintenance personnel estimates could not be accurately mapped into Aptitude Clusters. However, for a Concept Exploration Phase application of EMREM today, this maintenance reorganization would not present a problem.

b. Aggregate MOS Requirements into Aptitude Clusters

A review of the definitions of the Aptitude Clusters developed in Phase I, Task 2 of this study is included in Appendix A of this report.[9/] Where there were two or more MOS in a single cluster, the associated requirements were added to obtain the cluster totals.

The ORG echelon MOS for the AH-64 are found in two of the Aptitude Clusters, Technical and Mechanical Maintenance. This final step in the conversion to Aptitude Clusters is performed via a table look-up procedure. The final results of this conversion to Aptitude Clusters for both peacetime and wartime scenarios are summarized in Exhibits III-13 and III-14, respectively.

C. ANALYSIS OF THE AH-64 EMREM MANPOWER REQUIREMENTS ESTIMATES

As originally planned, part of this demonstration included a comparison of the estimates developed for the AH-64 using EMREM to comparable Army estimates. Examination of potentially comparable Army data has shown that no suitable estimate is currently available. Several Army estimates are usually appropriate for such a comparison, however, none of these are applicable in the case of the AH-64 for the following reasons:

- the AH-64 is not an Army Modernization Information Memorandum (AMIM) system,

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9/ The assignment of MOS to aptitude clusters is presented in the MCR technical report TR-8217-2, Aptitude Content of the Non-Prior Service Youth and Enlisted Apprentice Populations: 1982-2010, Management Consulting & Research, Inc., Falls Church, Virginia, 22041, 30 September 1983.

MOS	CLUSTER	EMREM ESTIMATE[1]	CLUSTER TOTAL
35	Technical	1	1
68J		0	
68J/M		0	
67R[2]	Mechanical Maintenance	0	2
68B		1	
68D		1	
68F		0	
68G		0	
68H		0	

1/ Estimate is for 18 AH-64 helicopters.

2/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

Exhibit III-13. AH-64 ORG LEVEL PEACETIME APPRENTICE MAINTENANCE PERSONNEL BY APTITUDE CLUSTER

MOS	CLUSTER	EMREM ESTIMATE[1] LOW	EMREM ESTIMATE[1] HIGH	CLUSTER TOTAL LOW	CLUSTER TOTAL HIGH
35	Technical	3	4	3	4
68J		0	0		
68J/M		0	0		
67R[2]	Mechanical Maintenance	1	2	6	8
68B		1	1		
68D		3	4		
68F		0	0		
68G		1	1		
68H		0	0		

1/ Estimate is for 18 AH-64 helicopters.

2/ MOS 67R has been changed to 67Y since the AH-64 Concept Exploration Phase.

Exhibit III-14. AH-64 ORG LEVEL WARTIME APPRENTICE MAINTENANCE PERSONNEL BY APTITUDE CLUSTER

- Quantitative and Qualitative Personnel Requirements Information (QQPRI) contained only remove and replace, not repair, maintenance data,
- Sample Data Collection (SDC) is not applicable since the AH-64 has not been fielded, and
- contractor prepared data were not specified by maintenance level.

For these reasons the EMREM estimates for the AH-64 cannot, at this time, be compared to any available Army estimate.

In the next section, the development of the EMREM estimate for the UH-60A helicopter is described.

IV. EMREM APPLICATION: UH-60A BLACK HAWK HELICOPTER

In this section we discuss application of EMREM to the Army's UH-60A Black Hawk helicopter. The UH-60A, which was fielded in June 1979, is a twin-engine, four-bladed helicopter designed to carry a crew of three and up to 11 combat-equipped troops. Eight troop seats are removable to allow room for four stretchers or cargo. Up to 8000 pounds of cargo can be carried on an external cargo hook. The primary missions of the UH-60A include tactical troop movement, medical evacuation, and tactical resupply. The UH-60A is designed to be capable of performing Army missions in all intensities of conflict and in all expected geographical environments.

The structure of this section parallels that of Section III and focuses on the two main parts in EMREM: the Hardware Characterization and the Manpower Requirements Estimation.

A. HARDWARE CHARACTERIZATION

The Hardware Characterization is described below in terms of the three steps comprising this analysis:

1. Identify the Baseline Weapon System,
2. Determine Baseline Weapon System Changes, and
3. Develop New Weapon System Description.

1. Identify the Baseline Weapon System

As described in the overview of the EMREM, the baseline system(s) act as a source for the hardware characterization and

analog manpower data for the new system. The use of baseline systems has been very similar in MCR's EMREM demonstrations on the M1 Abrams Main Battle Tank and AH-64 Helicopter. However, a slightly modified approach, also frequently necessary in very early resource analysis, has been used in the UH-60A analysis.

As noted in earlier discussions, EMREM is based largely on the application of comparability analysis of the new system hardware, performance and operational requirements to systems already fielded. To some extent some version of this approach is frequently at the foundation of the mission analysis which identified the need for the new system. While this is the advocated approach for formulating early manpower requirements estimates for the new system, it is not the only approach. Another method of developing estimates is to use detailed analyses of maintenance workload generated for each subsystem. These analyses are frequently developed by contractors as part of the early engineering design development. While such data are clearly not representative of actual field maintenance experience, they are sometimes the only data available, and are very useful for exploring early estimates of manpower requirements. They can provide useful projections of the manpower requirements the system would need if the engineering estimates are valid, and can still be used as an approach for considering potential system requirements. Program managers frequently use some type of similar analysis, performed using comparability analysis, to develop these estimates. The major difference may lie more in

the assumptions, data and calculation approach used in developing the engineering estimates, as apposed to adapting actual system data.

In the UH-60A EMREM analysis, the availability of useful baseline data provided a significant block to developing an estimate based on comparability analysis. Baseline systems are selected based on their relationship to the new system's DSARC I milestone date. It is desirable for the baseline system to have been fielded before the new system's DSARC I milestone. As indicated in Exhibit IV-1, this was achieved only for the UH-1H Iroquois multi-role utility and transport helicopter. While this would have been a very suitable primary baseline system, the lack of a sufficiently detailed historical data base is significant, as illustrated in Exhibit II-3. The only data for this system that are still available is information in an earlier version of AR 570-2 (Change 3), part of which includes UH-1H MACRIT data. These data are not sufficiently detailed to provide subsystem-specific maintenance manhour or manpower information. The same held true for original task force reports, which are usually insufficient as primary sources of EMREM input information. The TOE is also used for only certain portions of the analysis, relating to conversions of manhours to personnel and allocation of personnel to Aptitude Clusters.

In lieu of conventionally acceptable data, alternative sources for pre-DSARC I UH-60A data were sought. Based on the Utility Tactical Transport Aircraft System (UTTAS) study,

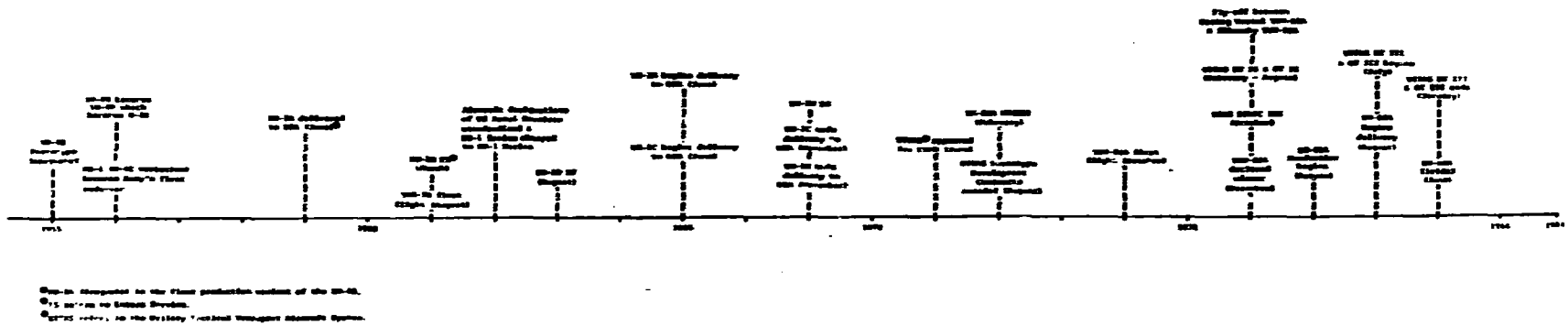

Exhibit IV-1. EVOLUTION OF U.S. UTILITY HELICOPTERS SINCE 1955.

Sikorsky and Boeing-Vertol developed prototypes, the YUH-60A and YUH-61A, respectively. The Sikorsky version (YUH-60A) was selected. That system became the UH-60A Black Hawk. Given the lack of historical baseline Army data, MCR chose to use as an alternative, engineering data developed by Sikorsky for the YUH-60A prototype. This system would bear a very close approximation to the mission need statement since it was designed, obviously, to be very closely related. The UH-1H was used as the secondary baseline for specific functions not represented in the Sikorsky analysis.

2. Determine Baseline Weapon System Changes

The second step in the hardware characterization is the isolation of the characteristics of the baseline system that are not similar to those related characteristics in the new system. Using the helicopter WBS developed for this analysis eight of the 10 subsystems were considered appropriate for use in analyzing the UH-60A pre-DSARC I requirements. Two of the subsystems, the fire control and armament, were not appropriate for use on the UH-60A since it was not originally planned to carry weapons. (It is currently being modified to carry HELLFIRE missiles, like the AH-64.)

In addition to the eight subsystems, analysis indicated that an additional maintenance function, technical inspection, needed to be separately represented. This was because this function was not estimated by Sikorsky. The technical inspection function is not system specific and is not assigned to any of the

subsystems. The Sikorsky design subsystems were arrayed to conform to the eight generic subsystems.

3. Develop New Weapon System Description

This step serves to refine the hardware characterization of the new system. In this case the mission need engineering statement for the UH-60A was reviewed in detail with hardware and performance data for the Sikorsky YUH-60A and supplementary information from the UH-1H. The eight subsystems used to describe the UH-60A hardware characterization are listed in Exhibit IV-2.

B. UH-60A EMREM MANPOWER REQUIREMENTS ESTIMATION

Based on the hardware characterization developed in the preceding section, manpower requirements estimates have been developed for the UH-60A. The organizational structure used for this purpose is a Combat Support Aviation Company (CSAC). Operator personnel (pilot, co-pilot, and crewchief/gunner) are excluded from this analysis because those positions are filled by warrant officers, and, in this application of EMREM, we are only concerned with enlisted personnel requirements. The requirements estimation process is discussed below in three parts:

1. Identify and Collect Data,
2. Develop Manpower Requirements Estimates, and
3. Translate Requirements Into Aptitude Clusters.

SUBSYSTEM	BASELINE SYSTEM [1]
Airframe/Landing Gear	YUH-60A
Rotor Group/Transmission	YUH-60A
Power Plant/Auxiliary Power Plant	YUH-60A
Hydraulics/Utilities	YUH-60A
Electrical System	YUH-60A
Flight Controls	YUH-60A
Instruments	YUH-60A
Avionics	YUH-60A
Fire Control/Automatic Test Equipment	YUH-60A
Armament	YUH-60A

[1] The LH-1G is not shown since it represents the Technical Inspection Function

Exhibit IV-2. FINAL BASELINE SUBSYSTEM SELECTION: UH-60A

1. Identify and Collect Data

As in the analysis performed for the AH-64, the availability of applicable manpower requirements data affected this analysis. As noted earlier, an original intention of this study was to develop manpower requirements estimates for each phase in a systems life cycle. The general lack of availability of historical data to support this type of analysis did not make such analysis possible, although data currently under development should be able to do so in the future. Thus, in this demonstration of EMREM, we were only able to generate an estimate of steady state maintenance manpower requirements for the UH-60A.

The data used for the UH-60A came from two sources, as noted in Exhibit IV-3. The primary source of data was the Sikorsky YUH-60A Maintainability Prediction Report. Data on the UH-1H technical inspection function came from Change 3 of AR 570-2. From each of these sources, subsystem-specific maintenance man-hours per flying hour were calculated and used as EMREM input data. To calculate the manpower requirements estimates, EMREM also utilizes the size of the organizational unit and usage rates. In this analysis, we estimated the below depot level maintenance manpower requirements to support 15 Black Hawks in a Combat Support Aviation Company (CSAC).

2. Develop Manpower Requirements Estimates

The manpower requirements estimates for the UH-60A, are calculated in the same six-step process as that used to develop the AH-64 estimates:

SUBSYSTEM	BASELINE SYSTEM	MANPOWER DOCUMENT USED[1/]
Airframe/Landing Gear	YUH-60A	Sikorsky YUH-60A Aircraft Maintainability Prediction Rep.
Rotor Group/Transmission	YUH-60A	" " " "
Power Plant/Auxiliary Power Plant	YUH-60A	" " " "
Hydraulics/Utilities	YUH-60A	" " " "
Electrical System	YUH-60A	" " " "
Flight Controls	YUH-60A	" " " "
Instruments	YUH-60A	" " " "
Avionics	YUH-60A	" " " "
Fire Control/Automatic Test Equipment	YUH-60A	" " " "
Armament	YUH-60A	" " " "

1/ Manpower data for the technical inspectors was obtained from change 3 of AR570-2.

Exhibit IV-3. FINAL BASELINE SUBSYSTEM SELECTION AND SOURCE OF MANPOWER DATA: UH-60A

- relate the baseline subsystems developed in the hardware characterization to their associated maintenance MOS,
- determine the organizational unit size,
- determine the applicable peacetime and wartime usage rates,
- calculate maintenance manpower requirements and allocate to appropriate maintenance echelons,
- convert maintenance manhour requirements to personnel requirements, and
- display manpower requirements estimates for peacetime and wartime scenarios.

Each of these steps in the UH-60A application is discussed below.

a. Relate the Baseline Subsystems to Associated Maintenance MOSs

As discussed in the analysis of the AH-64, the manpower requirements developed using EMREM must be grouped according to skills. The approach that was taken throughout this analysis was to relate hardware characteristics (and functions) to MOS. The relationship between hardware and MOS assignment for the UH-60A is shown in Exhibit IV-4. For those MOS which are not explicity subsystem-specific, such as Utility Helicopter Repairer (who in the senior pay grades may act as technical inspectors), the relevant MOS was deduced from AR 611-201. In instances where a single MOS serves multiple subsystems, the individual requirements for the MOS for each subsystem were calculated and added together.

b. Determine UH-60A Organizational Unit Size

Since the UH-60A Concept Exploration Phase, the H-Series TOE has been replaced by the current J-Series TOE,

MOS	OCCUPATION TITLE[1]	RELATED HARDWARD CHARACTERISTICS
35	Avionic Mechanic[2]	Flight Controls/Instruments/Avionics
67T[3]	Utility Helicopter Repairer	Various Subsystems/Inspections
68B	Aircraft Power Plant Repairer	Power Plant/Auxiliary Power Unit
68D	Aircraft Power Train Repairer	Rotor Group/Transmission
68F	Aircraft Electrician	Electrical System
68G	Aircraft Structual Repairer	Airframe/Landing Gear
68H	Aircraft Pneudraulics Repairer	Hydraulics/Utilities

1/ MOS codes and titles taken from AR611-201.

2/ This is a generic term referring to all the relevant avionic maintenance required on the UH-60A.

3/ This MOS is transitory replacing the 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-4. RELATIONSHIP OF MOS TO HARDWARE CHARACTERISTICS: UH-60A

resulting in a decrease in the number of helicopters per company from 23 to 15. This is a doctrinal change that could not have been predicted during the UH-60A's Concept Exploration Phase. Although this violates the intention of developing a "pure" Concept Exploration Phase estimate, the current size of the organization unit, the 15 helicopter company for the UH-60A, was used in all three of the EMREM analyses to date as the organizational unit for the manpower requirements estimates. Had the 23 helicopter company been used for the UH-60A, the manhour estimates would have been significantly increased.

c. Determine Applicable Peacetime and Wartime Usage Rates

For this application of EMREM two sets of usage rates, one reflecting a peacetime scenario, the other wartime, were used. The peacetime usage rate of 300 FH/Yr is based on information contained in the Army Modernization Information Memorandum (AMIM) and confirmed by the Department of the Army. It reflects the anticipated peacetime operating tempo. The wartime usage rate of 828 FH/Yr is based on information contained in the mission need statement. The wartime usage rate reflects the estimated operating tempo of a combat environment. In the subsections that follow the EMREM estimates are based on these two usage rates.

d. Calculate Manpower Requirements by Maintenance Level

Here, the manpower data is arrayed into the appropriate maintenance echelon. The doctrinal change from ORG, DS

and GS maintenance echelons to AVUM and AVIM could not have been anticipated during the UH-60A's Concept Exploration Phase, so the former arrangement has been used in this analyses.

The UH-60A maintenance manhour requirements for each maintenance echelon, ORG, DS, and GS are calculated using the maintenance manhour data for each of the subsystems or functions, as extracted from the Sikorsky data or AR 570-2, by MOS. The Sikorsky analysis included data for each maintenance echelon. The resulting estimates are shown in Exhibits IV-5 to IV-7. The estimates are presented by MOS for both peacetime and wartime scenarios. The baseline system selected is also indicated. The total of the annual maintenance manhours across MOS provides an overall picture of the maintenance intensity associated with each maintenance echelon. The maintenance manhours associated with MOS 67T include inspections done by senior personnel (i.e., technical inspectors).

Under a wartime scenario, the majority of the maintenance is performed at the ORG level. This enables a minimization of down time and a maximization of materiel readiness in a combat environment. At each maintenance echelon, the wartime maintenance manhours for the UH-60A are estimated to be approximately three times the manhours required during peacetime. Exhibit IV-8 illustrates, by MOS, the combined annual maintenance manhours required at ORG, DS and GS echelons.

In the next subsection we describe the conversion from maintenance manhour requirements to the number of personnel required.

MOS \ FH/Yr	EMREM ESTIMATE 1/ PEACETIME 300	WARTIME 828	BASELINE SYSTEM
35	506	1397	YUH-60A
67T 2/	10440	28814	UH-1H
68B	379	1047	YUH-60A
68D	1138	3142	YUH-60A
68F	295	815	YUH-60A
68G	1349	3724	YUH-60A
68H	506	1397	YUH-60A
TOTAL	14613	40336	-

1/ This estimate is for 15 UH-60A helicopters.

2/ This MOS is transitory replacing the 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-5. UH-60A ORG LEVEL ANNUAL MAINTENANCE MANHOUR ESTIMATE

MOS (FH/Yr)	EMREM ESTIMATE 1/ PEACETIME 300	WARTIME 825	BASELINE SYSTEM
35	129	357	YUH-60A
67T 2/	6507	17959	UH-1H
68B	329	908	YUH-60A
68D	179	494	YUH-60A
68F	75	208	YUH-60A
68G	152	419	YUH-60A
68H	71	195	YUH-60A
TOTAL	7442	20540	-

1/ Estimate is for 15 UH-60A helicopters.

2/ This MOS is transitory replacing the 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-6. UH-60A DS LEVEL ANNUAL MAINTENANCE MANHOUR ESTIMATE

MOS (FH/YE)	EMREM ESTIMATE 1/ PEACETIME 300	EMREM ESTIMATE 1/ WARTIME 825	BASELINE SYSTEM
35	3426	9457	YUH-60A
67T 2/	3636	10035	UH-1H
68B	217	599	YUH-60A
68D	1155	3187	YUH-60A
68F	11	31	YUH-60A
68G	152	419	YUH-60A
68H	150	415	YUH-60A
TOTAL	8747	24143	-

1/ Estimate is for 15 UH-60A helicopters.

2/ This MOS is transitory replacing the 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-7. UH-60A GS LEVEL ANNUAL MAINTENANCE MANHOUR ESTIMATE

MOS / MH/YR	EMREM ESTIMATE 1/ PEACETIME 300	WARTIME 628	BASELINE SYSTEM
35	4061	11211	YUH-60A
67T 2/	20583	56808	UH-1H
68B	925	2554	YUH-60A
68D	2472	6823	YUH-60A
68F	381	1054	YUH-60A
68G	1653	4562	YUH-60A
68H	727	2007	YUH-60A
TOTAL	30802	85019	-

1/ Estimate is for 15 UH-60A helicopters.

2/ This MOS is transitory replacing the 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-8. UH-60A TOTAL ANNUAL ORG, DS AND GS LEVEL MAINTENANCE MANHOUR ESTIMATE

e. Convert Manhours to Personnel

The conversion of manhours to numbers of personnel is accomplished by dividing annual manhour requirements by average available productive manhour (AAPMH) factors, such as those described in AR 570-2. Those factors reflect the estimated number of hours per year available for productive work by individuals engaged in particular levels of maintenance.

For peacetime ORG, DS and GS echelon maintenance and support personnel requirements calculations, the AR 570-2 TOE Categories I, II and III with 2500, 2700 and 3100 AAPMH, respectively, were used. For wartime ORG, DS and GS maintenance personnel calculations, the same TOE categories plus and minus 10 percent were used. This was done to reflect the various operating tempos in a combat environment and their effect on manpower.

While the quotient of the manhour requirements and the AAPMH factor need not be a whole number, the personnel authorizations for an organizational unit must be expressed in terms of whole people. Therefore, these quotients must be rounded. The same rules used in the AH-64 analysis for rounding of personnel have been used in the UH-60A analysis.

f. Display Manpower Requirements Estimates for Peacetime and Wartime Scenarios

Exhibit IV-9 summarizes the peacetime personnel requirements at ORG, DS and GS echelons. Only one number for personnel is shown because only one AAPMH factor was chosen. As indicated by Exhibit IV-9, some maintenance functions such as those performed by 67T, 68D, 68F, 68G and 68H are centralized at

MOS	EMREM ESTIMATE 1/ ORG (2500 / 300)	DS (2700 / 300)	GS (1100 / 300)	BASELINE SYSTEM
35	1	0	2	YUH-60A
67T 2/	4	3	2	UH-1H
68B	1	1	0	YUH-60A
68D	1	0	1	YUH-60A
68F	1	0	0	YUH-60A
68G	1	0	0	YUH-60A
68H	1	0	0	YUH-60A

1/ Estimate is for 15 UH-60A helicopters.

2/ MOS 67T transitory replacing 67N after the UH-60A Concept Exploratory Phase.

Exhibit IV-9. UH-60A ORG, DS AND GS LEVEL PEACETIME PERSONNEL REQUIREMENTS

the ORG level. Other maintenance functions, such as those performed by MOS 35 are deferred to the GS level.

Exhibit IV-10 summarizes the wartime personnel requirements at ORG, DS and GS. For wartime, based on the variation in the AAPMH factor, a range of personnel is generated. As with the AH-64 MOS 67T performing technical inspections, continues to have the largest allocation of personnel.

The final step in this analysis is the translation of these personnel estimates into requirements by Aptitude Clusters.

3. Translate Manpower Requirements to Aptitude Clusters

The final step in the development of the EMREM estimates involves the translation of the manpower requirements estimates by MOS into requirements by Aptitude Clusters. In this demonstration of the methodology, a subset of the total steady-state manpower requirements estimates was translated. This subset consists of ORG apprentice enlisted personnel, defined to be personnel at pay grades E-4 and below or at skill level 1. Only ORG apprentice personnel requirements could be mapped into Aptitude Clusters. The reasons are the same as those specified in the AH-64 analysis, namely the lack of sufficient DS and GS pay grade data for weapon system-specific manpower.

The translation of the EMREM estimates into Aptitude Clusters is performed by:

- determining the requirement for apprentice enlisted personnel, and

MOS	EMREM PERSONNEL REQUIREMENTS ESTIMATED[1/]						BASELINE SYSTEM
	ORG		DS		GS		
	LOW	HIGH	LOW	HIGH	LOW	HIGH	
	2250	2750	2430	2970	2790	3410	
	828	828	828	828	828	828	
35	1	1	1	1	3	4	YUH-60A
67T[2/]	10	12	6	7	3	4	UH-1H
68B	1	1	1	1	1	1	YUH-60A
68D	2	2	1	1	1	2	YUH-60A
68F	1	1	0	0	0	0	YUH-60A
68G	2	2	1	1	1	1	YUH-60A
68H	1	1	0	0	1	1	YUH-60A

1/ Estimate is for 15 UH-60A helicopters.

2/ MOS 67T is transitory replacing 67N after the UH-60A Concept Exploration Phase.

Exhibit IV-10. UH-60A ORG, DS AND GS LEVEL WARTIME PERSONNEL REQUIREMENTS

- aggregating requirements for apprentice personnel into Aptitude Clusters.

a. Determine Apprentice Enlisted Personnel Requirements

None of the documents that provided input data for the UH-60A demonstration of EMREM included pay grade or skill level information. However, this information could be ascertained for ORG maintenance personnel by examining an Assault Helicopter Company TOE. Thus, for the same reasons as for the AH-64, only requirements for UH-60A ORG-level apprentices could be aggregated to requirements by Aptitude Cluster. The TOE used for this purpose was TOE number 7-258H dated December 1971. That TOE contains personnel slots for ORG maintenance personnel associated with the UH-1H. This is a reasonable TOE to use since it was promulgated before DSARC I for the UH-60A, and, based on information in the UH-60A mission need statement, the types of maintenance personnel required for the UH-1H and the UH-60A should be similar.

The results of applying the same steps as used for the AH-64 to the UH-60A EMREM ORG level peacetime and wartime estimates are summarized in Exhibit IV-11.

b. Aggregate MOS Requirements to Aptitude Clusters

The final step in the translation of our estimates into Aptitude Clusters involves the mapping of the UH-60A MOS into Aptitude Clusters. The definitions of the Aptitude Clusters developed in this study are included in Appendix A of this report. Where there were two or more MOS in a single cluster we have added the associated requirements for the cluster totals.

EMREM PERSONNEL REQUIREMENT ESTIMATE[1/]

MOS[2/]	PEACETIME	WARTIME	
		LOW	HIGH
35	1	1	1
67R[3/]	1	2	2
68B	1	1	1
68D	1	2	2
68F	0	0	0
68G	0	1	1
68H	1	1	1

1/ Estimate is for 15 UH-60A helicopters.

2/ Operator personnel are excluded since they are Warrant Officers.

3/ MOS 67T is a transitory one, which replaced 67N after the UH-60A Concept Exploration Phase.

Exhibit IV-11. UH-60A ORG LEVEL APPRENTICE MAINTENANCE PERSONNEL REQUIREMENTS

The CRG level MOS for the UH-60A are found in two of the Aptitude Clusters, Technical and Mechanical Maintenance. This final step in the conversion to Aptitude Clusters is based on a previously developed table relating MOS to Aptitude Clusters. The results of this conversion for both peacetime and wartime scenarios are summarized in Exhibits IV-12 and IV-13, respectively.

C. ANALYSIS OF UH-60A EMREM MANPOWER ESTIMATES

As with the AH-64, it was originally intended that the estimates developed for the UH-60A using the EMREM would be compared to official Army estimates. Of the possible sources, the only detailed data currently available are from the AMIM. However, given the unusual nature of the estimate ultimately developed for the UH-60A, it was decided that any comparison to Army estimates might be misleading. For this reason no comparison has been made for the UH-60A.

In the next section the technological impacts considered in this analysis are summarized.

MOS	CLUSTER	EMREM ESTIMATE[1]	CLUSTER TOTAL
35	Technical	1	1
67T[2]	Mechanical Maintenance	1	4
68B		1	
68D		1	
68F		0	
68G		0	
68H		1	

1/ Estimate is for 15 UH-60A helicopters.

2/ MOS 67T is transitory replacing 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-12. UH-60A ORG LEVEL PEACETIME APPRENTICE MAINTENANCE PERSONNEL BY APTITUDE CLUSTER

MOS	CLUSTER	EMREM ESTIMATE[1] LOW	EMREM ESTIMATE[1] HIGH	CLUSTER TOTAL LOW	CLUSTER TOTAL HIGH
35	Technical	1	1	1	1
67T[2]	Mechanical Maintenance	2	2	7	7
68B		1	1		
68D		2	2		
68F		0	0		
68G		1	1		
68H		1	1		

1/ Estimate is for 15 UH-60A helicopters.

2/ MOS 67T is transitory replacing 67N since the UH-60A Concept Exploration Phase.

Exhibit IV-13. UH-60A ORG LEVEL WARTIME APPRENTICE MAINTENANCE PERSONNEL BY APTITUDE CLUSTER

V. SUMMARY AND CONCLUSIONS

This section includes a summary and comparison of the results of MCR's application of EMREM to the AH-64 and UH-60A helicopters. Also included is a summary of MCR's experience in using the EMREM to develop estimates of manpower requirements for the helicopters and conclusions we have drawn from this research. Many of the conclusions drawn here support observations and conclusions from our earlier application of EMREM to the M1 Abrams Main Battle Tank.

A. COMPARISON OF AH-64 AND UH-60A EMREM ESTIMATES

The major goal of this task was to demonstrate if sufficiently detailed estimates of manpower requirements could be developed using the EMREM approach to examine potential manpower impacts of technology. Two relatable systems were selected for this demonstration: the AH-64, representing the high technology system, and the UH-60A representing the low technology system. As discussed in the respective analyses for these systems, commonality between the two systems was encouraged, particularly in the selection of the vehicle power plant. Thus, it is possible that differences in technology may have been minimized between these two systems.

Exhibit V-1 shows the relationship of the hardware characteristics to the related MOS and occupation. This illustrates that the same MOS, with few exceptions, are used in both systems.

MOS	OCCUPATION TITLE	RELATED HARDWARE CHARACTERISTIC	HELICOPTER AH-64	HELICOPTER UH-60A
35	Avionic Mechanic[1/]	Flight Controls/Instruments/Avionics	X	X
67R[2/]	Attack Helicopter Repairer	Various Subsystems/Inspection	X	-
67T[3/]	Utility Helicopter Repairer	Various Subsystems/Inspection	-	X
68B	Aircraft Power Plant Repairer	Power Plant/Auxiliary Power Unit	X	X
68D	Aircraft Power Train Repairer	Rotor Group/Transmission	X	X
68F	Aircraft Electrician	Electrical System	X	X
68G	Aircraft Structural Repairer	Airframe/Landing Gear	X	X
68H	Aircraft Preudralics Repairer	Hydraulics/Utilities	X	X
68J	Helicopter Missile System Repairer	Pile Control/Automatic Test Equipment	X	-
68J/M[4/]	Helicopter Weapon System Repairer	Armament	X	-

1/ Generic term referring to all relevant avionics maintenance required on the helicopter.

2/ 67R changed to 67Y since AH-64 Concept Exploration Phase.

3/ 67T is a transitory MOS, replaced since the UH-60A Concept Exploration Phase by 67N.

4/ These MOS have been combined in this analysis since they both work on the armament and workload can not be differentiated.

Exhibit V-1. RELATIONSHIP OF AH-64 AND UH-60A MOS TO HARDWARE CHARACTERISTICS

The two differences are the MOS system designator for the helicopter repairer, which is 67R for attack helicopters and 67T for utility helicopters, and the presence of armament-related MOS on the AH-64 that are not now required on the UH-60A.

Exhibit V-2 compares the peacetime and wartime personnel requirements for the two helicopters. Included in this exhibit are notations on the reasons for significant differences between the two systems, in terms of the organizational units in which they will be deployed. The impact of deploying these systems together can not be gauged from this analysis, although it is possible that some of the same manpower could work on both of the systems.

As can be seen in this table, the AH-64 is expected to have significantly higher personnel requirements than the UH-60A, primarily due to the advanced avionics and electronics systems, and the presence of the HELLFIRE missile. Current plans to modify the UH-60A to carry similar armament could, conceivably, produce increases in selected manpower requirements.

B. SUMMARY

The purpose of this analysis was to further demonstrate the utility of EMREM as a means of establishing manpower estimates for major weapon systems prior to DSARC Milestone I. In an earlier report,[10/] MCR documented the application of EMREM on the

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10/ TR-8217-3, Demonstration of the Early-On Manpower Requirements Estimation Methodology: M1 Abrams Main Battle Tank, Management Consulting & Research, Inc., 30 September 1983.

MOS	PEACETIME[1]		WARTIME				Comments
			Low		High		
	AH-64	UH-60A	AH-64	UH-60A	AH-64	UH-60A	
35	2	3	18	5	23	6	Additional Avionics on AH-64
67R	3	-	8	-	10	-	
67T	-	9	-	19	-	23	
68B	2	2	2	3	2	3	
68D	5	2	20	4	26	5	Advanced low-maintenance rotors on UH-60A
68F	6	1	25	1	34	1	Additional electronics equipment on AH-64
68G	1	1	2	4	3	4	
68H	4	1	11	2	14	2	
68J	2	-	4	-	5	-	
68J/M	2	-	33	-	43	-	HELLFIRE Missile and additional armament on AH-64
TOTAL	27	19	123	38	160	44	

1/ Personnel required to maintain 18 AH-64 helicopters and 15 UH-60A helicopters.

Exhibit V-2. COMPARISON OF TOTAL EMREM PEACETIME AND WARTIME ESTIMATES: AH-64 AND UH-60A

M1 Abrams Main Battle Tank. The current application provides further verification that manpower requirements estimates for major systems can be developed, in the case of the Army, well before DSARC Milestone II, the point at which these estimates are normally developed. How much earlier depends on a number of considerations. Since the basis of the EMREM estimation technique is comparability analysis, the principal determinant of when the methodology can be applied is the availability of data on what we have termed the baseline subsystems. Based on our applications of the methodology, we have found that:

- the amount of detail available for early weapon system manpower estimates varies significantly from program to program;
- the development of estimates of peacetime and wartime manpower requirements varies from program to program;
- the ability to perform comparability analysis depends on identification of baseline hardware characteristics and manpower data that are related to the evolution of the new system design;
- subsystem-level data are sufficient for making early estimates, but information on more specific performance characteristics is useful for comparative purposes; and
- the same general categories of data sources are useful, regardless of the system being analyzed, however the quantity and quality of program-specific data vary significantly.

Based on this experience, a preliminary list of minimum data requirements has been developed. In order to make early estimates of manpower requirements for the new system being developed, the analyst needs:

- a description of the required performance characteristics, if possible, by subsystem,

- planned usage rates, preferably for both wartime and peacetime operating scenarios,
- the type and size of the organizational unit in which the system will be deployed,
- the planned size of the crew or intended number of operators per system, and
- the concept of operations and maintenance (wartime and peacetime separately, if they will be different).

In addition to these data on the new system, specific data are also required on the baseline system or systems, including:

- reliability and maintainability parameters and values for each baseline subsystem,
- system and subsystem (wartime and peacetime) usage rates,
- the quantity of manpower by occupational type and skill-level required by the system, within the organizational unit in which it is deployed,
- the (wartime and peacetime) concept of operations and maintenance, and
- any system-peculiar maintenance characteristics of the fielded system.

While these are minimum data required to effectively estimate weapon system manpower requirements early-on, it is important to keep in mind that additional data are always desirable. Therefore, development of data bases such as those described in MIL-STD-1388-1A will almost certainly increase the effectiveness of the estimate development.

As noted in the discussion of the data availability, distinctions must be made among data currently generated by the Army in the Concept Exploration Phase, data developed in the AH-64 and UH-60A Concept Exploration Phases, and data now obtainable from the earlier period. The incompleteness of the historical file of

Concept Exploration Phase data severely influenced MCR's development of a "pure" pre-Milestone I estimate for the two helicopters. However, documents available at that time would have allowed the development of such an estimate. Since that time, the Army has instituted the development of new data systems such as the AMIM and Sample Data Collection which will facilitate much more effective estimating for future systems. In addition, programs are underway to significantly improve the Army's early weapon system manpower requirements estimating. For these reasons we believe that early estimates can be developed using existing documentation.

However, the current ability to produce a comprehensive array of life cycle manpower estimates is somewhat impaired in the current documentation process. This is largely due to the lack of sufficiently detailed longitudinal data on subsystems, and that limits the ability to effectively interpret the stage in the system life cycle represented by the data. Because the comparability analysis requires utilization of historical data on baseline systems, this strongly influences the development of life cycle estimates. Implementation of the MIL-STD-1388-1A requirements for development of system life cycle estimates will greatly enhance the Services' capability to produce similar manpower estimates.

Finally, concerning the question of the level of detail sufficient to generate a reasonable estimate, these demonstrations show that major subsystem data are sufficient. While detailed data on components are useful for distinguishing similar

subsystems from one another, alternative technical data sources were found to be sufficient. Also, in the very early stages of a system design, the only data available may be at the level of major subsystems, and these may frequently be tentative.

C. CONCLUSIONS

The following are MCR's conclusions regarding the development and demonstration of the Early-On Manpower Requirements Estimation Methodology (EMREM).

- EMREM is an effective method for examining the manpower implications of different technologies early in the system design process.
- The EMREM approach developed in this study is consistent with the comparability analysis outlined in MIL-STD-1388-1A. The types of data required for EMREM are similar to those developed in the LSA with the following exceptions:
  - EMREM requires generally less detailed data on subsystems.
  - EMREM analysis is intended to be performed in a particular phase of the system acquisition, generally earlier than the LSA manpower requirements analysis is to be performed.
  - MCR believes that it is desirable to perform this analysis as early as possible in the acquisition process, since the information produced can contribute to the development of a more supportable system. Particular analytical requirements of LSA can be effectively supported by the results of this analysis.

APPENDIX A

OVERVIEW OF APTITUDE CLUSTER DEFINITIONS

This study has involved the development of methodologies for estimating the long-term supply of manpower and the demand for military enlisted manpower. In order to ultimately relate the projected manpower supply to the projected manpower demand, a mechanism for translating these estimates into common terms was necessary. This mechanism is the Aptitude Cluster. The Aptitude Cluster is intended, at an aggregate level, to represent those characteristics and capabilities identified as "necessary" for the performance of particular military jobs, by each of the Services. It reflects the common relationships (i.e., similarity of aptitude requirements based on combinations of subtests) of aptitude composites among the Services. As such, the Aptitude Cluster, as opposed to the aptitude composite, is non-Service specific. The cluster represents the common characteristics shared by several composites.

Given the ability to relate Services' aptitude composites to each other and to represent them at a more aggregate level, it is possible to translate weapon system-specific manpower requirements to the related Aptitude Cluster. In this translation, the distinctions which are made at the Service level among occupations are blurred, so that those occupations which use the same "types" of people are collectively represented as a single "type" of requirement. Conceivably, within the Services as well as among the Services, competition occurs for "types" of people to support specific occupational requirements.

The Aptitude Clusters can also be applied to the manpower supply projections as a mechanism for tailoring, or characterizing, the projected population. This is necessary in order to add another dimension to the population, the distribution of those capabilities which the population may have and which the Services need in their apprentices. In this use, the Aptitude Clusters are used in conjunction with historic ASVAB scoring data to show the overall distribution of aptitudes in the projected population.

Given the aggregate nature of the Aptitude Clusters, it was necessary to identify the characteristics common among the Services' composites. The distribution and variety of subtest combinations clearly indicated that the subtest level of detail was not a functional level at which to identify common characteristics. Initial examination and review for discussion of the content of the subtests indicated that it was possible to group the subtests. This grouping is based on the similarity of the knowledge groups the subtests are addressing. There are two studies which have statistically analyzed these relationships.[1/]

Four groups of subtests were used:

- Math, composed of Arithmetic Reasoning (AR) and Math Knowledge (MK);
- Speed, composed of Numerical Operations (NO) and Coding Speed (CS);

1/ Dr. Darrell Bock of the University of Chicago has studied these relationships using the 1980 "Profile of American Youth" data. The Army Research Institute analysis is documented in "Factor Structure of the Armed Services Vocational Aptitude Battery (ASVAB), Forms 8, 9 and 10: 1981 Army Applicant Sample."

- Verbal, composed of Paragraph Comprehension (PC), Word Knowledge (WK), and General Science (GS); and
- Technical, composed of Electronic Information (EI), Mechanical Comprehension (MC), and Automotive Shop (AS).

The relationships identified in the Profile of American Youth data were selected since they are based on the same data base used in developing MCR's manpower supply projections. The Services' aptitude composite/subtest combinations were arrayed according to these subtest groupings and are shown in Exhibit A-1.

As noted earlier, all four Services have three composites which are structurally composed of the same set of subtests and are, therefore, common to all. These are the General, Administrative/Clerical and Electronics composites. Using the subtest grouping approach, it can be seen, however, that there are additional cases of common characteristics. Since the subtests are grouped, these common relationships are based on the combination of subtests in a group. Therefore, although one composite may use one subtest in a group, and another composite may not use the first subtest but does use another subtest in the same group, the two composites are considered related. Based on this analysis of subtest selections by group, all of the composites have been related to each other and assigned to a cluster.

As discussed earlier, some analytical judgement has been used in defining and assigning the Navy composites. Analysis at the subtest level assigned a number of very skilled electronics

APTITUDE CLUSTER	SERVICE	APTITUDE COMPOSITE	ASVAB SUBTESTS									
			MATH		SPEED		VERBAL			TECHNICAL		
			AR	MK	NO	CS	PC	WK	GS	EI	MC	AS
General	Army	General Technical	X				X	X				
	Navy	General (Basic)	X				X	X				
	Navy	General (Electronics)	X	X					X			
	Marine Corps	General Technical	X				X	X				
	Air Force	General	X				X	X				
Administrative/ Clerical	Army	Clerical			X	X	X	X				
	Navy	Administrative			X	X	X	X				
	Marine Corps	Clerical			X	X	X	X				
	Air Force	Administrative			X	X	X	X				
Technical	Army	Electronics	X	X					X	X		
	Navy	Electronics	X	X					X	X		
	Marine Corps	Electronics	X	X					X	X		
	Air Force	Electronics	X	X					X	X		
	Army	General Maintenance		X					X	X		X
	Marine Corps	General Mechanical		X					X	X		X
	Army	Skilled Technical		X			X	X	X		X	
	Navy	Skilled Technical	X				X	X			X	
	Marine Corps	Field Artillery	X				X	X			X	
	Navy	Nuclear	X	X			X	X	X	X		X
Mechanical	Navy	Mechanical Technical					X	X			X	X
	Air Force	Mechanical							X		X	X
Mechanical Maintenance	Army	Mechanical Maintenance	X							X	X	X
	Marine Corps	Mechanical Maintenance	X							X	X	X
Combat	Army	Field Artillery	X	X		X					X	
	Army	Combat	X			X					X	X
Field	Army	Operators/Food			X		X	X			X	X
	Army	Surveillance/Communic.			X	X	X	X				X
	Marine Corps	Combat			X		X	X				X

Exhibit A-1. RELATIONSHIP OF APTITUDE COMPOSITES TO APTITUDE CLUSTERS

occupations to the Navy Skilled Technical and Electronics composites, although structurally they were not quite compatible. Analysis according to subtest groups allowed for the splitting out of these occupations into a separate composite, called here General (Electronics).

In addition to combinations of subtests, aptitude composites are also defined by the minimum combined scores required to qualify for occupations (i.e., training) in the composite. Within the composite, individual occupations are assigned minimum required scores. In order to determine the proportion of the population qualifying in each aptitude composite, it was necessary to select criteria for this qualification. A minimum combined score was identified for each aptitude composite based on analysis of the occupation qualification scores used by each Service. (The list of apprentice occupations in each Service by Aptitude Cluster and minimum score is included in the MCR Report Aptitude Content of the Non-Prior Service Youth and Enlisted Apprentice Populations: 1982-2010, TR-8217-2, Appendix C.) In those cases where large differences exist in the minimum combined score requirements for groups of occupations in a composite, the composite was restructured for this analysis to reflect this. Thus, the Navy/General (Basic) and Navy/General (Electronics) composites belong to the same cluster, based on the analysis of their subtest requirements. However they are different composites, not only due to differences in subset combinations, but also due to the large differences in the score requirements. A single minimum combined score was determined, based on analysis of the

overall bottom end of the score range, for each service composite in each cluster. These are shown in Exhibit A-2. These combinations of subtests and scores, expressed as individual composites and as cluster qualification scores, were used as the basis for refining the population projections of the non-prior service youth (17-21 years old) and the military enlisted apprentice populations.

In order to develop the aptitude composite and cluster qualification rates for the NPS youth and enlisted apprentice populations, the definitions of the composites and clusters were applied to three data bases. The Profile of American Youth study was used to represent NPS youth, also referred to here as the civilian population. The enlisted apprentice rates were developed from analysis of the FY81 and FY82 military accession data bases. The composite and cluster qualification definitions were applied to these data bases through a two-step process to produce the qualification rates used in the third part of the PROMANSA model.

In the first step, the test results in the three data bases were reviewed to determine if the individuals in the selected age groups met the minimum combined score requirements in each composite. Based on this analysis, composite qualification rates were developed for the NPS youth and enlisted apprentice populations.

In the second step, the Aptitude Cluster qualification rates were developed. Within each cluster, there may be more than one combination of subtests making up the various composites in the

Aptitude Cluster	Service	Aptitude Composite	Related ASVAB Subtests	Minimum Score[a]	Application Rules
General	Army	General Technical	AR PC MK	N/A	• Not Applicable to Classif.
	Navy	General (Basic)	AR PC MK	90	• 90 for Basic Ratings
	Navy	General (Elect.)	AR MK GS	200 ←	• 200 for Gen. Elect. Ratings
	Marine Corps	General Technical	AR PC MK	92	• Combined Scores
	Air Force	General	AR PC MK	87 ←	• Combined Scores
Administrative/ Clerical	Army	Clerical	MO CS PC MK	138	• Combined Scores
	Navy	Administrative	MO CS PC MK	149	• Combined Scores
	Marine Corps	Clerical	MO CS PC MK	131 ←	• Combined Scores
	Air Force	Administrative	MO CS PC MK	142	• Combined Scores
Technical	Army	Electronics	AR MK GS EI	175 ←	• Combined Score
	Navy	Electronics	AR MK GS EI	156/212	MK+GS+EI=156(+AR=212)
	Marine Corps	Electronics	AR MK GS EI	182	• Combined Scores
	Air Force	Electronics	AR MK GS EI	181	• Combined Scores
	Army	General Mtnce	MK GS EI AS	177 ←	• Combined Scores
	Marine Corps	General Mech	MK GS EI AS	N/A	• Not Applicable to Classif.
	Army	Skilled Technical	MK PC MK GS MC	178 ←	• Combined Scores
	Navy	Skilled Technical	AR PC MK MC	146 ←	• Combined Score with Multiple Rating-Specific Variations
	Marine Corps	Field Artillery	AR PC MK MC	139 ←	• Combined Scores
	Navy	Nuclear	AR PC MK GE MK EI AS		
			AR PC MK	115	• Must meet all of these qualifications
			AR 2MK GS	200 ←	
			AR MK GS EI	156/218	MK+GS+EI=156(+AR=218)
			MK AS	94	
Mechanical	Air Force	Mechanical	GS MC AS	173 ←	• Combined Scores
	Navy	Mechanical Tech.	PC MK MC AS	145 ←	• Combined Scores
Mechanical Maintenance	Army	Mech. Mtnce	AR EI MC AS	179	• Combined Scores
	Marine Corps	Mech. Mtnce	AR EI MC AS	167 ←	• Combined Scores
Combat	Army	Field Artillery	AR MK CS MC	177 ←	• Combined Scores
	Army	Combat	AR CS MC AS	178 ←	• Combined Scores
Field	Marine Corps	Combat	MO PC MK AS	131 ←	• Combined Scores
	Army	Operators/Food	MO PC MK MC AS	180 ←	• Combined Scores
	Army	Surveillance/Comm	MO CS PC MK AS	191 ←	• Combined Scores

[a]Minimum Score=Sum of Standard Scores

Exhibit A-2. DEFINITIONS OF MCR APTITUDE CLUSTERS

cluster. In order to determine the qualification rates for the seven clusters, it was necessary to determine if individuals qualified in any one of the different combinations of subtests included in the cluster. Seventeen unique subtest combinations were identified within the 26 composites. These 17 combinations were used to determine the cluster qualification rates. For example, in order to qualify for the Technical cluster, an individual could qualify in any one of six ways. The arrows in Exhibit A-2 show the 17 subtest combinations used to develop the Aptitude Cluster qualification rates.

APPENDIX B

EMREM PROGRAM DOCUMENTATION

This appendix documents the computer program used to calculate the weapon system manpower estimates developed in the second part of EMREM (see Exhibit II-2). The program is written in Apple-soft BASIC and has been run on the Apple II microcomputer. The program consists of a short main program and four subroutines. The main program is primarily responsible for reading the input data.

The first subroutine is an interactive data input section. The user is prompted to supply the crucial parameters pertaining to the new weapon system and the organizational unit into which this system is to be deployed. Specifically, the user is first asked to enter the lower and upper bounds for the new weapon system usage rate. For the helicopter applications, the unit of measure for the usage rate is flying hours per year. The user is then prompted to supply the lower and upper bounds for the annual available productive manhour (AAPMH) factor. This factor, which varies by maintenance echelon, allows the conversion of annual maintenance manhour data to numbers of personnel. The final prompt in this subroutine asks the user to supply the number of weapon systems anticipated to be deployed into the organizational unit.

The second subroutine calculates the number of persons from each MOS group required to meet the scheduled and unscheduled maintenance requirements at each echelon below the depot level, as well as the total below depot level requirement. That calculation explicitly accounts for the number of weapon systems in the organizational unit.

There are a number of assumptions incorporated in the calculations that deserve elaboration. The most salient of them is that manpower requirements are directly proportional to the usage rate; i.e., doubling the usage rate doubles the associated maintenance manhour requirements. This seems a reasonable assumption when applied to small (relative) fluctuations in the usage rate. It is, however, a concession to data availability. Another assumption concerns the rounding of non-integer personnel figures into more meaningful integer values. That is, after dividing the required AAMH (for a given MOS) by the AAPMH factor, the result is an integer plus some fraction. We impose a couple of rules that apply in the conversion of this figure into an integer. The first of these assumptions can be interpreted in the following way. Let N be the number of weapon systems in the organizationl unit. Then, if the rounding to the greatest integer less than or equal to (N*AMMH)/AAPMH implies that each of the associated personnel must absorb an additional ten percent or more work load (due to rounding), then the figure may be evaluated for potential rounding upward to the next higher integer. This leads tos the second rule imposed on rounding. The program does not allow the upward rounding if the result is that each of the associated personnel is contributing less than 90 percent of the lower AAPMH factor input. The product of the second subroutine is the number of below-depot-level maintenance and support personnel required for each MOS group. This estimate is determined for each of the four scenarios that reflect the pairwise combinations of the two extreme usage rates and AAPMH factors.

The third subroutine compares the EMREM below depot level estimates to the most recent observations on the weapon system to which EMREM is being applied. This subroutine determines where the benchmark (realized) manpower requirements lie with respect to the EMREM estimate interval. This subroutine allows expedient isolation of those MOSs (and, hence, subsystems) for which EMREM is proving to be less accurate. This will allow us to critically evaluate our choice of input data.

The fourth subroutine is essentially a report writer.

The baseline program may be modified or augmented so as to most fully exploit the data available for EMREM applications to other weapon systems.

```
1  REM   ********     EMREM PROGRAM     ********
2  PRINT  CHR$ (4)"BRUN AMPER INTERPRETER"
3  TEXT : HOME
4  REM   INITIALIZATION STATEMENTS
5 A = 0:B = 0:C = 0:D = 0:E = 0:F = 0:G = 0:H = 0:I = 0:J = 0:K = 0:L = 0
    M = 0:N = 0
6 P = 0:Q = 0:R = 0:S = 0:T = 0:U = 0:V = 0:W = 0:X = 0:Y = 0:Z = 0
7  HOME : SPEED= 160: FOR I = 1 TO 10: PRINT : NEXT : PRINT "                *
    *** EMREM ****       ": HOME : PRINT "          ": SPEED= 255
8  REM    DIMENSION STATEMENTS
9  REM
10  DIM C1$(30),C2(30),A1(30),A2(30),A3(30),A4(30),LL$(30),CV(30)
12  DIM H1(30),H2(30),P1(10,30),P2(10,30)
13  DIM MS$(30),MI(30),MH(30),B$(30),S$(30)
14 BELL$ = ""
15  REM    READ STATEMENTS
16  REM
17  READ SY$,U$,NO
18  FOR I = 1 TO NO: READ MS$(I),MI(I),MH(I),B$(I),S$(I): NEXT
19  READ CS$,ML$,N1
20  FOR J = 1 TO N1: READ C1$(J),C2(J): NEXT
21  REM
22  REM    ****** ESTIMATE INPUT DATA ******
23  DATA  AH-64,FLYING HRS/YR,9
24  DATA  68G,1,.032,AH-56,AAHTF
25  DATA  68D,1,.350,AH-56,AAHTF
26  DATA  68B,1000,84 33,YUH-60A,SIKOR.
27  DATA  68H,1, 000,AH-1G,AR570-2
28  DATA  68F,1,.000,AH-1G,AR570-2
29  DATA  35 ,1,.629,AH-56,AAHTF
30  DATA  68J,1,.036,AH-56,AAHTF
31  DATA  68J/M,1,3.061,AH-56,AAHTF
32  DATA  67R,1,.813,AH-56,AAHTF
54  REM    ************************************
55  REM
56  REM    ******** COMPARISON DATA ********
57  REM  DUMMY DATA FOR COMPARISON
58  DATA  FY82 GJPRI,1,1
59  DATA  68G,100
95  REM    ************************************
96  REM
97  REM
98  REM
99  REM     ------------------------------
100  REM   PROMPT USER FOR SCENARIO INPUT
101  REM    ------------------------------
110  GOSUB 1000
115  REM
119  REM    ------------------------------
120  REM   CALCULATE MANPOWER REQUIREMENTS
121  REM    ------------------------------
130  GOSUB 2000
135  REM
139  REM    ------------------------------
140  REM   COMPARE ESTIMATES WITH ACTUALS
141  REM    ------------------------------
150  GOSUB 3000
```

```
155   REM
159   REM     **********************
160   REM    GENERATE OUTPUT REPORT
161   REM     **********************
170   GOSUB 4000
175   REM
180   END
190   REM
200   REM
210   REM
```

```
1000  REM      <<<<<< PARAMETER INPUT SUBROUTINE >>>>>>
1001 ER$ = "ERROR -- LOWER WAS => UPPER!"
1002  PRINT BELL$: HOME : FOR I = 1 TO 6: PRINT : NEXT I
1003  PRINT "  ";: INVERSE : PRINT "      RECORD KEEPING INFORMATION
     ": PRINT : PRINT
1004  NORMAL : PRINT "  ";: INVERSE : PRINT "TODAY'S DATE (MO/DA/YR)":: INPUT
     D$
1005  PRINT : NORMAL : PRINT "  ";: INVERSE : PRINT "PURPOSE:"
1006  NORMAL : PRINT "     1  ORG ECHELON RUN": PRINT "     2   DS ECHELON R
     UN": PRINT "     3   GS ECHELON RUN": PRINT : PRINT "  ";
1007  INVERSE : PRINT "YOUR CHOICE?";: GET H: IF H < 1 OR H > 3 THEN  HOME
     : FOR I = 1 TO 10: PRINT : NEXT : GOTO 1005
1008  IF H = 1 THEN PP$ = "ORG ECHELON RUN"
1009  IF H = 2 THEN PP$ = "DS ECHELON RUN"
1010  IF H = 3 THEN PP$ = "GS ECHELON RUN"
1011  FOR I = 1 TO 3: PRINT BELL$
1012  HOME : PRINT : PRINT : INVERSE : PRINT SY$"-RELATED PARAMETER INPUT
     SECTION": NORMAL
1015  PRINT BELL$
1020  PRINT : PRINT : SPEED= 180: PRINT "ENTER UPPER AND LOWER BOUNDS FOR"
     : PRINT SY$" USAGE RATE "
1030  PRINT : PRINT "LOWER BOUND = ";: INPUT M1: PRINT "UPPER BOUND = ";: INPUT
     M2: PRINT : PRINT
1040  IF M2 > M1 GOTO 1060
1050  SPEED= 255: FOR I = 1 TO 2: PRINT BELL$: NEXT : SPEED= 25: PRINT : PRINT
     ER$"     ": HOME : GOTO 1020
1060  PRINT  SPC( 5)"*****************************" SPC( 5)
1065  PRINT BELL$
1070  PRINT : PRINT : SPEED= 180: PRINT "ENTER UPPER AND LOWER BOUNDS FOR"
     : PRINT "AAPMH FACTOR "
1080  PRINT : PRINT "LOWER BOUND = ";: INPUT F(1): PRINT "UPPER BOUND = ";
     : INPUT F(2): PRINT : PRINT
1090  IF F(2) > F(1) GOTO 1110
1100  SPEED= 255: FOR I = 1 TO 2: PRINT BELL$: NEXT : SPEED= 25: PRINT : PRINT
     ER$"     ": HOME : GOTO 1070
1110  REM
1115  PRINT BELL$
1120  HOME : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT "ENTER ANTICIPA
     TED NO. OF "SY$"S" : PRINT "PER ORGANIZATIONAL UNIT.";: INPUT N
1125  FOR I = 1 TO 3: PRINT BELL$: NEXT
1130  SPEED= 100  HOME : FOR I = 1 TO 10: PRINT : NEXT : INVERSE : PRINT "
      --- NOW CALCULATING REQUIREMENTS --- ": NORMAL : SPEED= 255
1135  RETURN
1140  REM
1150  REM
```

```
2000  REM      <<<<<< CALCULATION SUBROUTINE >>>>>>
2005  REM    CALCULATE TOTAL MANHOUR REQUIREMENTS FOR ORG UNIT
2010  FOR J = 1 TO NO
2020 H1(J) = N * (M1 / MI(J)) * MH(J)
2030 H2(J) = N * (M2 / MI(J)) * MH(J)
2040  NEXT
2045  REM    CHECK FOR EXCESSIVE WORKLOAD DUE TO DOWNWARD ROUNDING
2050  FOR I = 1 TO 2: FOR K = 1 TO NO
2060  IF (H1(K) / F(I) -  INT (H1(K) / F(I))) / ( INT (H1(K) / F(I)) + .00
      01) > .1 GOTO 2060
2070 P1(I,K) =  INT (H1(K) / F(I)) GOTO 2090
2080 P1(I,K) =  INT (H1(K) / F(I)) + 1
2090  IF (H2(K) / F(I) -  INT (H2(K) / F(I))) / ( INT (H2(K) / F(I)) + .00
      01) > .1 GOTO 2110
2100 P2(I,K) =  INT (H2(K) / F(I)): GOTO 2120
2110 P2(I,K) =  INT (H2(K) / F(I)) + 1
2120  NEXT K: NEXT I
2125  REM    CHECK FOR DIMINUTIVE WORKLOAD
2130  FOR I = 1 TO 2: FOR K = 1 TO NO
2140  IF H1(K) / (P1(I,K) + .00001) < .1 * F(I) THEN P1(I,K) = P1(I,K) - 1

2150  IF H2(K) / (P2(I,K) + .00001) < .1 * F(I) THEN P2(I,K) = P2(I,K) - 1

2160  IF P1(I,K) < 0 THEN P1(I,K) = 0
2170  IF P2(I,K) < 0 THEN P2(I,K) = 0
2200  NEXT K: NEXT I
2900  RETURN
2998  REM
2999  REM
```

```
3000  REM      <<<<<< COMPARISON SUBROUTINE >>>>>>
3315  REM    DETERMINE WHETHER ESTIMATE INTERVALS CONTAIN BENCHMARK DATA
3320  FOR I = 1 TO N1:X = 0
3330 X = X + 1
3335  IF X =  ) NO + 1 THEN LL$(I) = "EMREM DID NOT ANTICIPATE THIS MOS GR
     OUP.":CV(I) = 8: GOTO 3400
3340  IF C1$(I) = MS$(X) THEN  GOTO 3380
3350  GOTO 3330
3380  REM   THERE IS A MATCH BETWEEN COMPARISON AND EMREM MOS CODE
3385  IF C2(I) =  ) (H1(X) / N) AND C2(I) =  ( (H2(X) / N) THEN LL$(I) = "
     YES": GOTO 3400
3390 LL$(I) = "NO": IF C2(I) ( H1(X) / N THEN CV(I) = 1: GOTO 3400
3395 CV(I) = 2
3400  NEXT I
3980  RETURN
3990  REM
3995  REM
```

```
4000  REM      <<<<<< REPORT WRITING SUBROUTINE >>>>>>
4001  PR# 1
4002  PRINT  CHR$ (9)"80N": PRINT  CHR$ (27)"E"
4003 Y1$ = "(EMREM LOWER BOUND TOO HIGH.)":Y2$ = "(EMREM UPPER BOUND TOO L
     OW.)"
4004 NC$ = "  NOTE: #PERS. INVARIANT TO USAGE RATE, AAPMH FACTOR RANGE LIM
     ITS AFTER ROUNDING.":FT$ = "  (SEE NOTE.)
4006 S1$ = "NOTE: EMREM PREDICTED ":S2$ = " RELEVANT MOS GROUPS THAN "
4007 F1$ = "FRMT,$3;":F2$ = "FRMT,X10,5.2,0:":F3$ = "FRMT,X10,5.2,0;":F4$ =
     "FRMT,$15;"
4008 F5$ = "FRMT,X7,5.0,0.0,": PRINT  CHR$ (12)
4009  PRINT : PRINT : PRINT  SPC( 6)"**************************************
     **************************"
4010  PRINT  SPC( 6)"* EMREM MAINTENANCE & SUPPORT MANHOUR REQUIREMENTS ES
     TIMATES *"
4011  PRINT  SPC( 6)"**************************************************
     *********"
4015  PRINT  CHR$ (27)"E"
4020  PRINT : PRINT : PRINT : PRINT  SPC( 28)SY$" APPLICATION": PRINT : PRINT
      PRINT
4060  PRINT  SPC( 28)"AMMH"
4070  PRINT  SPC( 16)"MOS" SPC( 5)"LOW" SPC( 5)"HIGH" SPC( 6)"BASELINE SYS
     "
4075  FOR K = 1 TO NO
4080  PRINT  SPC( 16): & PRNT,MS$(K),F1$: & PRNT,H1(K),F2$: & PRNT,H2(K),F
     3$: & PRNT,B$(K),F4$: PRINT  SPC( 3): PRINT
4085  NEXT K
4090  FOR I = 1 TO 8: PRINT : NEXT
4091  PRINT  SPC( 35)"SCENARIO": PRINT  SPC( 16)"ESTIMATE" SPC( 6)"AAPMH" SPC(
     4)"USAGE RATE ("U$")"
4092  PRINT  SPC( 18)"LOW" SPC( 10)F(2) SPC( 8)M1
4093  PRINT  SPC( 17)"HIGH" SPC( 10)F(1) SPC( 8)M2
4094  PRINT : PRINT : PRINT  SPC( 16)"ORG. UNIT SIZE = "N" "SY$"'S."
4097  FOR I = 1 TO 14: PRINT : NEXT : PRINT  SPC( 45)"DATE: "D$
4099  PRINT  SPC( 45)"PURPOSE: "PP$
4200  REM
4201  PR# 1: PRINT  CHR$ (9)"80N": PRINT  CHR$ (12)
4202  PRINT : PRINT
4204  PRINT  SPC( 4)"**************************************************
     ************"
4205  PRINT  SPC( 4)"* EMREM MAINTENANCE & SUPPORT PERSONNEL REQUIREMENTS
     ESTIMATES *"
4206  PRINT  SPC( 4)"**************************************************
     ************"
4210  PRINT : PRINT : PRINT  SPC( 30)SY$" APPLICATION": PRINT : PRINT : PRINT

4215  PRINT  SPC( 18)"MOS" SPC( 4)"LOW" SPC( 3)"HIGH" SPC( 6)"BASELINE"
4220  FOR I = 1 TO NO
4240  PRINT  SPC( 18): & PRNT,MS$(I),F1$: & PRNT,P1(2,I),F5$: & PRNT,P2(1,
     I),F5$: & PRNT,B$(I),F4$: PRINT  SPC( 3): PRINT
4260  NEXT I
4271  FOR I = 1 TO 8: PRINT : NEXT
4272  PRINT  SPC( 35)"SCENARIO": PRINT  SPC( 16)"ESTIMATE" SPC( 6)"AAPMH" SPC(
     4)"USAGE RATE ("U$")"
```

```
4273  PRINT  SPC( 18)"LOW" SPC( 10)F(2) SPC( 8)M1
4274  PRINT  SPC( 17)"HIGH" SPC( 10)F(1) SPC( 8)M2
4275  PRINT : PRINT : PRINT  SPC( 16)"ORG. UNIT SIZE = "N" "SY$"'S."
4276  FOR I = 1 TO 14: PRINT : NEXT : PRINT  SPC( 45)"DATE: "D$
4277  PRINT  SPC( 45)"PURPOSE: "PP$
4278  PRINT
4290  SPEED= 100: PRINT : PRINT : PRINT : PRINT "IF YOU WOULD LIKE TO HAVE
      A COMPARISON REPORT, ENTER 1.": SPEED= 255
4300  GET U: IF U = 1 THEN  GOTO 4400
4310  GOTO 4990
4400  REM   COMPARISON REPORT PRINT STATEMENTS (OPTIONAL)
4405  PR# 1: PRINT  CHR$ (12): PR# 1
4410  PRINT  CHR$ (9)"80N"
4430  PRINT  SPC( 22)"*** COMPARISON SUMMARY ***"
4440  PRINT : PRINT : PRINT  SPC( 26)SY$" APPLICATION": PRINT  SPC( 26)"BE
     NCHMARK DATA SOURCE: "CS$
4450  PRINT : PRINT : PRINT
4460  IF NO > N1 THEN  PRINT S1$"MORE"S2$;: PRINT CS$","
4470  IF NO < N1 THEN  PRINT S1$"FEWER"S2$;: PRINT CS$","
4480  PRINT : PRINT
4500  PRINT "  MOS GROUP" SPC( 12)CS$" VALUE IN EMREM INTERVAL?"
4505  PRINT
4510  FOR J = 1 TO N1
4520  PRINT  SPC( 6)C1$(J) SPC( 24)LL$(J);
4530  IF CV(J) = 1 THEN  PRINT "  "Y1$
4540  IF CV(J) = 2 THEN  PRINT "  "Y2$
4545  IF CV(J) <  =  > 1 AND CV(J) <  =  > 2 THEN  PRINT " ": PRINT
4550  NEXT J
4990  PRINT  CHR$ (12)
4999  RETURN
```

APPENDIX C

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